GAS JOURNAL

LIGHT ⁘ HEAT ⁘ POWER ⁘ BYE-PRODUCTS

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Editorial Notes.

The New "Gas Salesman."

DURING a brief pause in the preparations for getting this issue of the "JOURNAL" to press, the writer has allowed his mind to wander back to a time in the not dim, but distant, past, when the junior members of the industry were busy forming their own Associations. This was round about thirty years ago, and it marked the beginning of a movement the success of which has far exceeded the most optimistic anticipations that could then have been cherished. The Junior Gas Associations have grown in strength and multiplied, and so enviable has their record been that there is not a single session of any Association which has not improved upon the preceding ones. For this success we take some credit to ourselves; for the columns of the "JOURNAL" over all the intervening years have been placed freely at the disposal of the various organizations, and have provided that "fresh air and sunlight"—otherwise publicity—without which it is doubtful whether they would have survived, and far less likely that they would have thrived. What we have done we were more than willing to do; for we recognized from the very first the enormous possibilities with which the movement was fraught—for the industry at large, as well as for the juniors themselves. It has been our pleasure at increasingly frequent intervals to receive papers and reports of discussions at the meetings of these organizations which would be a credit to any Senior Society, and to see members of the Junior Associations step out into the higher ranks of the industry.

Much more recently, another departure has been inaugurated—this time in the interests of those engaged solely on the selling side of the industry. We refer, of course, to the Gas Salesmen's Circles, the formation of which has placed us all under so great an obligation to the British Commercial Gas Association. Here, again, the "JOURNAL" was quick to perceive a further field of usefulness to the industry, and full reports of Circle meetings have been a feature of the periodical "Gas Salesman" Supplements. We are convinced that the benefit of these reports to the gas salesman is on a par with those enjoyed through similar publicity by the members of the Junior Gas Associations, and that the "Gas Salesman" already forms an essential part of the literature of the industry. That its usefulness can be still further increased we are equally sure, and as a first move in this direction, as already announced, we have decided to issue the "Gas Salesman" as a publication entirely independent of the "JOURNAL." In this way it can be improved in appearance, and the greater amount of space available will permit of a more ambitious programme.

The first issue of the "Gas Salesman" in its new form is now in the press, and will be posted towards the end of this week. We ask all into whose hands it may come to peruse it carefully and form an opinion as to whether it is likely to be of value to the selling side of their undertakings. To those who may think it is, we appeal for whole-hearted support in this further effort on our part to Serve.

Corrosion and Protective Coatings.

STATISTICS can be illuminating, and they can also be highly misleading. Generally, statistics on the elusive, yet most important, problem of corrosion of mains and services fall into the latter class. We have, for example, waded through much data (scientifically wrought) which appear to prove conclusively that such-and-such a material offers the greatest resistance to corrosion—as witness the fact that between the year X and the year Y no pitting had taken place, and therefore the material Z must be *par excellence*.

Now, on the surface such information has seemed plausible, but it has only been "on the surface." In other words, bearing in mind the extraordinary—albeit little appreciated—surface effects of various soils on different materials used for mains and services, we have on occasion "seen through" the jungle foliage of mathematical calculations, and have found these calculations (with added graphs) interesting in themselves only. This is very sad; it is also very true, which may be synonymous. At all events, it is the reason why we call attention to a serious and well-written contribution by Mr. F. N. Speller in later columns to-day.

Mr. Speller's article is entitled "Corrosion—A Problem in Protective Coatings." The title is essentially right, according to our viewpoint, for we thoroughly agree with the author that retardation of corrosion is generally brought about by the formation of more or less impermeable protective coatings on anodic areas of mains and services. We go so far as to say that our aim should be to cultivate this valuable property in metals; and we certainly think that metals having high corrosive resistance may be better developed by a scientific study of the stability and formation of surface films than by the old cut-and-dried method of making and testing the effects of various alloy elements.

The point to bear in mind is that external influences predominate in controlling the corrosion rate of any metal. It is useless for wrought iron in one area to be compared with steel laid in an area entirely different as regards the soil influences; and, this being true, it is important to understand the various ways in which the rate of attack is governed by changes in external conditions, including the surface films which naturally form on a metal surface and tend to re-form when broken by a self-healing

process. The essential characteristic of a rust-resisting metal is that it should form impermeable, tenacious, and stable surface films in combination with corroding media; these films are usually much more stable than the metals which enter into their structure.

All this being true, we may be pardoned for quoting the author's idea that, to improve the durability of iron, the compounds of iron and other metals most resistant under certain conditions of service should first be investigated, and then the most likely ones selected in an endeavour to form solid solutions of iron and other metals which will form resistant films when the metal corrodes. The chief alloying metals available in practice are copper, nickel, chromium, silicon, and aluminium. Since double compounds of these metals are as a rule more stable, a research of this kind is likely to take time and patience. However, much has already been learned by experience, and useful alloys of iron, chromium, and nickel are now available for various purposes where first cost is of secondary importance. A low-priced alloy is needed which will be two or three times as durable as ordinary iron in air or soil without much additional cost. When such an alloy (comparatively cheap, be it noted) is secured, we shall be less concerned about corrosion not only of mains and services, but also of flue equipment generally.

Soot on Buildings.

THE outside of St. Paul's Cathedral is dirty. Some like the æsthetic effect of this dirt; others deplore it. All, however, must recognize that it is due to the deposit of soot, and that this deposit is extremely harmful to stonework. It has been suggested recently that the exterior of this famous building should be cleaned, and the reply has been given that the stone found protection in its coating of soot. This remark is a half-truth scientifically; and we feel called upon to amplify it. The removal of the present deposit on St. Paul's might be dangerous, since it would remove the "skin" of the stone, and perhaps leave weak spots to suffer extremely under further attacks. This is very different from saying that soot is a good thing for the preservation of our buildings. Quite the reverse holds true.

We have before us the evidence of Sir Frank Baines, who, as Director of H.M. Office of Works, discussed in 1924 the ravages caused by soot deposit to buildings made of Portland stone, which is the constructional material of St. Paul's. Here is an actual quotation from one of his lectures: "The greasy, sooty impurities in "the atmosphere destroy the natural colour of stones or "bricks, while the acid impurities cause decay and erosion "of surfaces and mouldings, and all carved and distinc-"tive detail. . . . The buildings in Whitehall occupied "by the Ministry of Health were erected in 1908. The "stone has been exposed for approximately sixteen years "only, and decay has been so rapid that the softer por-"tions have been worn away to a depth of at least ½ in. "If a rate of decay as rapid as this had taken place upon "all buildings in London constructed of Portland stone "since the beginning of the 17th century (when Portland "stone came into common use), it is obvious that there "would have been little, if any, of the original detail left "for our enjoyment."

We hope the foregoing will set right any misconception that soot is good for stonework. Incidentally, the amount involved in the actual maintenance and repair of official buildings is approximately £1,570,000 per annum; and Sir Frank Baines estimated that, at the very least, £120,000 a year could be saved on the maintenance of official buildings in charge of H.M. Office of Works, if the air were as pure in towns as it is in rural districts. Gas is helping to attain this ideal.

Recent Evidence.

A REPORT on smoke abatement prepared by a Sub-Committee of the Science Standing Committee of the Royal Institute of British Architects has just been issued. Striking evidence, the report states, has been given as to the serious damage occasioned to public and other buildings by smoke and other impurities in the atmosphere. The damage is mainly due to the sulphurous and sulphuric acids contained in the products of combustion, but particles of soot united with these acids materially enhance their injurious effect. The acids become concentrated, and the tarry content of the soot makes the mixture more adhesive.

In such buildings as the Houses of Parliament, Buckingham Palace, Somerset House, and Chelsea Hospital, what are the normally good weathering stones are being rapidly disintegrated by the acid soot. It has been given in evidence that the upkeep of public monuments and buildings would be reduced by at least one-half if a pure and smoke free atmosphere could be obtained. Sulphuric acid particularly corrodes or disintegrates practically all kinds of building materials. Marble tends to turn green and then black. The absorption of sulphur gases by limestones resulting in the formation of gypsum is, in this country at least, the most potent cause of their decay.

The Sub-Committee find that sulphur in the atmosphere will be minimized by the universal use of gas or electricity; and in a list of recommendations addressed to architects, the report points out that coke, weight for weight, when reasonably free from moisture and ash, can be used for heating effects in open sitting-room grates. The efficiency of good coke as a fuel, its relative cheapness, and its freedom from smoke, together constitute advantages for the sake of which it is worth while to overcome the slight difficulties in regard to its use. We would observe that the "slight difficulties" are removed by the adoption of grates designed to burn coke and by employing gas for its ignition. And we would mention that, in the last fifteen years, London's sootfall has been more than halved, and that during the same period the number of gas appliances in use has been more than doubled. Finally, as a smoke (visible and invisible) abater, gas is far more efficient than electricity, produced from coal. There is virtue in the expression, "electricity and purer air," but even those who employ it must bear in mind that the sulphur from over 8 million tons of coal is poured into the atmosphere to make the electricity consumed in this country.

British Industries Fair.

Intimations being received daily by the Birmingham Chamber of Commerce (Inc.) from business houses abroad make it clear that the numbers of foreign visitors to the Heavy Section of the British Industries Fair, opening in Birmingham on Feb. 17, will be largely in excess of those on any previous occasion. This year at least 3000 entirely new British products of interest, collectively, to every trade in the country, will be seen in the Birmingham Section.

The Coal Mines Bill.

To the views of the gas industry on the Coal Mines Bill may be added those of the British Engineers' Association, who have unanimously passed the following resolution: "The Council of the British Engineers' Association objects to the basis of the Coal Mines Bill, now under consideration, being convinced that Government intervention in the conduct of the industry is against the general interests of industry; and in this particular case the Council is extremely apprehensive of its effects on the engineering industry, and fears a further increase of unemployment resulting from a consequential diminution of our exports of manufactured goods." The Council also records its opinion that the unhappy state of the coal industry is "only one of many manifestations of the evil consequences of politicizing an industry and embracing false economics, and that the restoration of prosperity to our industries will be achieved only by the application of genuine remedies to the root-causes of the disease, and not by sporadic action dictated by considerations of political expediency."

Views of the Federation of British Industries.

Having now had an opportunity of consulting industry on the subject of the Coal Mines Bill, the Federation of British Industries is in a position to state that the Bill is not only wholly unacceptable to industry, but arouses the gravest apprehensions as to its effect, if ever put into operation, upon the

industrial well-being of the country. It is remarked that "restraint of trade by Act of Parliament is a strange doctrine for a Government which has already announced its intention of establishing a Consumers' Council. Nor is it easy to appreciate how a State-sanctioned increase in the cost of one of industry's primary raw materials can assist in what is still, presumably, the Government's main industrial policy—the reduction of unemployment. Never has the principle of bureaucratic interference been enunciated in a more vicious form." An appeal is made to the Government to reconsider, even at this stage, its position.

City and Guilds of London Institute.

The report of the work of the Department of Technology of the Institute for the session 1928-29 has just been published, and it is good to learn that many more students presented themselves for the examinations in Gas Fitting than was the case in the previous session—the numbers being 804 and 480 respectively. It is stated in the report that the great increase in the entries for Grade II. and the Final Grade of Gas Fitting taxed to the utmost the resources of the Department for the provision of the Local Examiners required for the practical tests; the panels furnished by the District Gas Education Committees in certain areas having been exhausted. At one centre the Department were enabled to overcome the difficulty through the good offices of the Gas Light and Coke Company. The services of a large number of competent Examiners from the Company's staff were lent for the occasion. The following figures relating to the examination results are interesting. In the Minor Course in Gas-Works Practice, there were 11 candidates, of whom 4 failed to satisfy the Examiners. In the corresponding course in Gas Supply Practice, there were 85 candidates, 33 of whom failed to pass the examination.

Slagging of Refractories.

In some vertical retort settings, said Dr. J. A. Sugden in a paper before the Yorkshire Juniors last Saturday, the lower courses of the retort built in firebrick are put to a very severe test. A firebrick may contain 3 p.ct. or more of ferric oxide, which is reduced to the ferrous form by the strongly reducing atmosphere of steam. Ferrous oxide slags easily with silica, and this explains the bad running of the brickwork which sometimes occurs in steaming. The tendency will be less with materials containing less iron oxide, but with most materials troublesome roughening of the surface occurs. The steaming process probably transfers some iron oxide from the ash in the coke to the refractory, and in this way increases the slagging action.

Giving Away £1,000,000!

In spite of the Ministry of Transport's advocacy of the use of only British materials on British roads, the Board of Trade Returns for December (just published) show a considerable increase in bitumen imports as compared with the corresponding month of the previous year. Last month more than 13,000 tons of foreign asphalt and bitumen were brought into England from abroad compared with 7000 tons in December of 1928. During the past year nearly £1,000,000 has been diverted from this country for products which are being used on our roads to displace tar, produced by British labour from British materials.

An Effect of the New Companies Act.

A development of the Companies Act of 1929 to which the "Financial Times" calls attention is the conversion of various public companies into private ones, and the withdrawal of permission to deal in the shares. It is pointed out that the new Act grants private companies special privileges and immunities which give the enterprises greater freedom of action.

Growing Popularity of Waterless Holders.

At the beginning of this year, 203 gasholders of the "M.A.N." type had either been erected or were in course of construction, and their total capacity was no less than 552 million c.ft. Germany led the way with 86 holders; the United States was second with 41, and Great Britain came third with 20. The total capacity of "M.A.N." holders in Great Britain was approximately 57 million c.ft.

Group Benefits.

What constitutes a small-sized social revolution is quietly taking place in the British paint and varnish industry. Some months ago the employers' federation in this industry conducted an exhaustive study of group life assurance and pension schemes which could be adapted to fit the varying circumstances of member firms in co-operation with their employees. As the result of that study, a standard plan was adopted; and it is meeting with so much approval from employers and employees alike that the time may be said to be within sight when the entire industry will have these benefits, altogether additional to those provided under the National Health, Old Age Insurance, and other Acts. The rapid extension of these schemes means that, in addition to the national social services, an important industry with a large number of workers is providing for itself a modern, scientific, and thoroughly sound means of abolishing the fear of impoverishment through the death of the bread-winner and of dependency in old age. The remarkable thing about them is the manner in which so many benefits can be secured at very low cost, through the use of unity and co-operation.

Forthcoming Engagements.

[*Secretaries of Gas and Kindred Organizations are asked to assist in making this diary of events as complete and useful as possible by sending the earliest intimation of all meetings.*]

Jan. 24.—BRITISH COMMERCIAL GAS ASSOCIATION.—Annual meeting of members in Scotland, North British Station Hotel, Glasgow, 2.15 p.m.

Jan. 25.—SCOTTISH JUNIOR GAS ASSOCIATION (WESTERN DISTRICT).—Meeting in Glasgow. Paper by Mr. Alex. Tran, of Helensburgh, "Some Notes on Ferro-Concrete." Also, Mr. A. McFarlane will read his Thesis which gained the Diploma of the Institution of Gas Engineers.

Jan. 30.—MIDLAND JUNIOR GAS ASSOCIATION.—Meeting in Birmingham. Paper by Mr. C. Featherstone Hammond, of Messrs. Submerged Combustion, Ltd., on "Submerged Combustion."

Jan. 31.—LONDON AND SOUTHERN DISTRICT JUNIOR GAS ASSOCIATION.—Meeting at the Westminster Technical Institute. Paper by Mr. G. Percival on "Horizontal Retorts."

Feb. 10.—MIDLAND ASSOCIATION OF GAS ENGINEERS AND MANAGERS.—Annual dinner and dance.

Feb. 11.—FEDERATION OF GAS EMPLOYERS.—Quarterly meeting of Central Committee, 28, Grosvenor Gardens, S.W. 1.

Feb. 11.—NATIONAL GAS COUNCIL.—Meeting of Central Executive Board.

Feb. 11.—INSTITUTION OF GAS ENGINEERS.—Meeting of Gas Education Executive Committee, 4 p.m.

Feb. 12.—INSTITUTION OF GAS ENGINEERS.—Meetings of Executive Committee, 10 a.m.; Finance Committee, 12 noon; Benevolent Fund Committee of Management, 12.20 p.m.; Council, 2 p.m.

June 2-5.—INSTITUTION OF GAS ENGINEERS.—Annual Conference in Leeds.

Gas Undertakings Acts.—We have received from Messrs. Sweet & Maxwell, Ltd., a copy of "The Law Procedure and Practice relating to the Gas Undertakings Acts, 1920 and 1929," by H. Royston Askew, B.Sc. Eng., Assoc.M.Inst.C.E., A.C.G.I. A review of the book (the price of which is 30s. net) will appear later in the "JOURNAL." It may, however, be added here that it contains chapters on the "Finance of Standard Price Revision," by George Evetts, M.Inst.C.E.

Gas Company's Youthful Guests.—Over a thousand London children were entertained to tea last week at the East Greenwich Institute of the South Metropolitan Gas Company. The children, whose parents or other relatives are employed by the Company, were divided into two groups, and each child was accompanied by a relation. About 1200 guests were present last Wednesday afternoon, and about 1000 on Thursday. Tea was followed by a cinema entertainment, a pantomime, and games.

In To-Day's "Journal."

Refractories.

Dr. J. A. Sugden, of Leeds University, discusses in a general manner the subject of gas-works refractories. He mentions that the most important high-temperature insulating material is kieselguhr or diatomaceous earth. Its testing and use is at present being investigated by the Research Committee of the Institution of Gas Engineers, and its application is likely to become more general in the future.

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Combustion, Wind, and Flue Equipment.

Concluded in our issue to-day is Mr. C. A. Masterman's valuable treatise on combustion, wind, and flue equipment in which he gives an expression for determining, for a flue of given area or diameter, the critical height at which the products of combustion will be completely removed and sufficient draught provided to meet combustion requirements in all normal circumstances. The author deals with induced downdraught and the subject of condensation in flue equipment.

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Protective Coatings for Mains.

Corrosion of mains may be prevented, or at any rate minimized, in three different ways: By developing more resistant metals; by reducing the corrosive character of the environment; or by the use of more stable protective layers of material. It is with this latter method that a paper by Mr. F. W. Speller, of the National Tube Company, Pittsburg, deals in our issue to-day. The conclusions arrived at, based on American research and practice, show that there are certain chemical protective coatings which become more resistant to corrosion when they come into contact with the corrosive elements. The relative corrodibility of wrought-iron, steel, and pure iron is also discussed.

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Gas at the Cookery and Food Exhibition.

Gas once again occupies a major place at the Cookery and Food Exhibition now in progress at Olympia, and a summary of some of its uses is contained in a brief survey on later pages. The London Gas Exhibit Committee are once more well to the fore in holding competitions in cake making, while an interesting feature is the exhibit of a gas-fired fish frying range, displayed in conjunction with the British Trawlers' Federation.

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Standard Specifications for Benzole and Allied Products.

Dr. W. B. Davidson reviews the National Benzole Association's latest publication in the shape of "Standard Specifications for Benzole and Allied Products, 1929." The methods of testing have been prepared by the Standardization of Tar Products Tests Committee, and they have been handed, in advance of publication, to the National Benzole Association in order to avoid delay in issuing these specifications. The book can be obtained from the Headquarters of the Association, Wellington House, Buckingham Gate, S.W. 1, at 6s. net. A great deal of energy has been expended by the Association in the preparation of this work, and it is gratifying to learn that the response has been good, and that there has been a big demand for copies.

On the Electrical Side.

Scheme for South-West England and South Wales.

An area of no less than 17,234 square miles (which at the last census had a population of over six millions) is covered by the electricity scheme for South-West England and South Wales which has been prepared by the Electricity Commissioners. The district included is the whole of South Wales, the counties of Hereford, Monmouth, Somerset, Devon, Cornwall, Dorset, Wiltshire, and Southampton, parts of the counties of Berkshire, Gloucestershire, Oxfordshire, and West Sussex, and the Isle of Wight. The Commissioners point out that the scheme embraces densely populated areas in the coal mining districts; the important maritime towns of Southampton, Plymouth, Falmouth, Bristol, Newport, Cardiff, and Swansea; the growing industrial districts around Swindon, Bristol, Bath, Stroud, Frome, and Melksham; the china clay districts in Cornwall and Devon; and the tin mining district in West Cornwall. Under the scheme, six existing stations and two new stations (one in the neighbourhood of Southampton and one in South Wales) will be operated for the Central Electricity Board. The six stations now in operation which have been selected are at Cardiff, Hayle, Newport (Mon.), Portishead (Bristol), Southampton, and Upper Boat (South Wales). In addition, the scheme provides for the working, if necessary, of eleven other generating stations under temporary arrangements between the Central Board and the owners. In providing for the future demands in the area, it is contemplated that the base load output will be allocated as far as posible to the selected stations at Portishead and Upper Boat; and that the remaining requirements will be met by the four other selected stations, with the assistance of those worked under temporary arrangements.

Plans and Cost.

The generating stations will be inter-connected by high-pressure main transmission lines, designed in a series of ring mains, so that there will be alternative routes to points of supply, and consequently greater security against breakdown. The main transmission system will comprise 622 route miles of line and 25 transforming stations. The secondary transmission will involve a further 11 transforming stations. The inter-connection of these stations will, it is stated, result in the release for revenue-earning purposes of about 180,000 KW. of generating plant now kept as spare, and representing about £3,060,000 of capital. The transmission system for the South-Western area will connect-up through Reading, and possibly also along the South Coast, with the system of the Central Board in South-East England, and through Worcester with the system of the Board in Central England, thus becoming a contributory portion of the comprehensive system for Great Britain. The scheme contemplates the standardization of twenty undertakings, including the South Wales Electrical Power Distribution Company and the Cornwall Electric Power Company, at an estimated cost of £764,450. The cost of the scheme to the Board for the erection of the transmission system is estimated at £4,163,484. In addition, there will be an expenditure by undertakers of about £1,934,360 on extensions of certain existing stations. It is estimated that the full advantages of the scheme can be secured with a saving of about £1,383,506 on capital expenditure (up to the year 1936-37), compared with the capital expenditure that would be necessary if the present system were continued. After this date the saving on capital expenditure would, it is stated, be progressively greater compared with individual development.

Views on the Proposals.

This is the seventh regional scheme prepared by the Commissioners; and the seven schemes account for 94 p.ct. of the area of England and Wales, and 98 p.ct. of the population. The remaining scheme for East England, comprising the county of Norfolk and practically the whole of Suffolk, is in hand. North and South Scotland have yet to be dealt with.

Sir Harry Haward (one of the Electricity Commissioners) has expressed the view that as a result of this seventh scheme, consumers in the area concerned may look forward to a reduction in the charges for electricity. Writing in the "Financial Times," Mr. Hugh Quigley points out that there has been no attempt to extend into the counties of Wiltshire, Dorset, and Somerset; while South Wales, outside the industrial part, is left untouched. In his opinion, therefore, the scheme must be considered as one of the least progressive of all those yet evolved by the Electricity Commission; and if it is to be of any value in the future economic expansion of the territory, it will require very considerable extension.

The South-East England Scheme.

Just when news of the latest proposals is attracting attention, we are told of the grave anxiety felt in a part of Kent, with regard to surveys for a section of the South-East England electricity scheme. These surveys, it would appear from a message sent by the special correspondent of "The Times," imply a threat to the beautiful north-eastern Weald of Kent and a hitherto unspoiled stretch of the Pilgrims' Way; and though it has been pointed out that they are preliminary, experience in the matter of the Sussex Downs is by no means re-assuring. While such strenuous efforts are being made to "popularize" electricity, it is unfortunate that antagonism should be aroused by the making of plans which are so keenly resented. The famous beauty spots of the country are dear to others besides "vested interests"—on which it is fashionable to lay the blame for protests against the intrusion of extra high-pressure overhead lines, carried on steel towers, 80 ft. high, at intervals of 300 yards. Where alternatives may be available, the ignoring of public feeling will in the long run probably prove expensive to the electricians. It may be men-

tioned that the South-East England electricity scheme covers an area of 8828 square miles, with a population of more than 11 millions.

Vagaries of the "Grid."

Even when the "grid" system does get to work, the results are not invariably everything that could be desired. An instance of this kind is revealed at Cheltenham, where users of current from the bulk supply taken from the Shropshire Power Company, whose generating station is at Stourport, have been paying for the privilege in inconvenience, as well as in hard cash. "Intolerable" inconvenience, it is termed by the leader writer of a local paper, who goes on to say: "This is the penalty we have to pay for 'progress'—so called. The consumers affected are exclusively those who get their supply from Stourport, as delivered in bulk to the Cheltenham Corporation. The considerable parts of the town which have not yet been linked-up with the 'grid' system are enjoying a constant and efficient service. . . . The transmission of energy over great distances is the essential feature of the national system—a system from which we are led to expect the blessings of widely distributed and cheapened electricity. But there is already experience to prove that transmission by overhead cables may be highly unsatisfactory. The method is 'economical,' but this is the most abused word in the dictionary. In point of fact, it is only an illustration of the cheap and nasty."

Personal.

The late Mr. WILLIAM NIELD BICKERTON, a Director of the National Gas Engine Company, Ltd., who left £60,477 (net personalty £56,002), donated 5000 ordinary shares in the Company "for the benefit of employees who shall be in distress or need of assistance." An obituary notice appeared in the "JOURNAL" shortly after Mr. Bickerton's death.

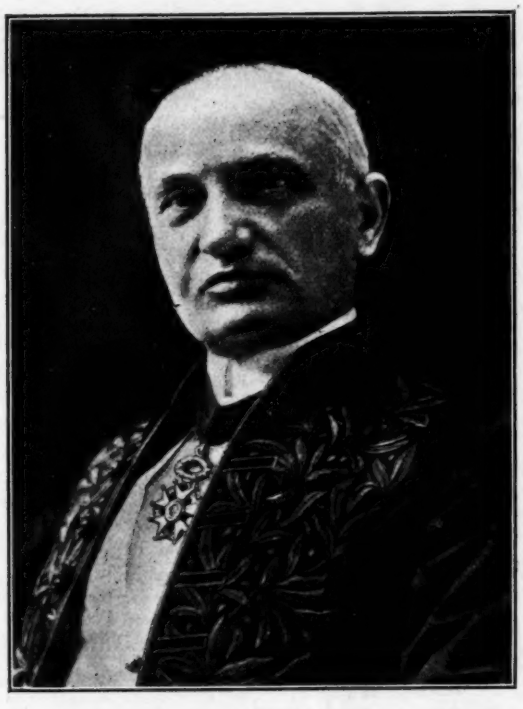
It is announced that Mr. GEORGE NEIL, who has been for some time on the staff of the Engineering Department of the Newcastle and Gateshead Gas Company, has been appointed Chief Works Assistant (under Mr. J. R. Bradshaw, B.Sc.) to the Hartlepool Gas and Water Company.

Mr. GILBERT GLEDHILL, a Director of Messrs. G. H. Gledhill & Sons, Ltd., of Halifax, and the Gledhill-Brook Time Recorders, Ltd., of Huddersfield, has been adopted by the Halifax Conservative Association as their prospective candidate. At the last election Mr. Gledhill increased the Conservative vote by 65 p.ct., as compared with the by-election eight months previously, and secured second place in a three-cornered fight.

Obituary.

PROF. RATEAU.

The death has taken place of Prof. Auguste C. E. Rateau. He was born in 1863 in Royan, and was educated at the Grammar School of Cognac, and at the Ecole Polytechnique and the Ecole des Mines in Paris.



THE LATE PROF. AUGUSTE C. E. RATEAU.

In the nineties, Prof. Rateau worked incessantly on the development of the impulse steam turbine. Single stage turbines were first built according to his plans, and in 1897 he designed a turbine consisting of two impulse wheels working in series. In 1900, at the World Exhibition in Paris, the first complete set of drawings, together with parts, of a 1000-B.H.P. multi-stage impulse turbine intended for a torpedo boat were submitted to the Committee; this may be considered as the first typical multi-stage Rateau turbine. After having obtained such important results in high-pressure condensing turbines, Prof. Rateau turned his attention to the designing of steam accumulators, and low-pressure turbines capable of utilizing the exhaust steam from reciprocating engines.

The best-known contribution of Prof. Rateau to the technique of the gas engineer is the centrifugal gas exhauster, which has been built under licence for this country by the Bryan Donkin Company, Ltd., and which takes the shape of either a single or double inlet one-stage fan, or a multi-stage blower in which the various stages work in series, the inlet of a stage being connected to the preceding one by an S-shaped return channel. The latest invention of Prof. Rateau for exhausters and boosters was the star type machine, in which the fan wheel built up by riveted flanges and blades is replaced by one solid impeller, and in which the blades are entirely cut out from the solid. As it is possible to run the star impeller at twice the peripheral speed of the built-up impeller, while maintaining the stresses at a lower limit, it therefore becomes practically possible to replace a four-stage exhauster by a single-stage machine, with a consequent gain in simplicity of construction, reliability, space requirements, and cost. This type of machine has been extensively used both in Great Britain and abroad as gas exhauster and as gas booster, with excellent results.

Prof. Rateau held the Doctor's Degree of the University of Birmingham, the University of Wisconsin (U.S.A.), and the University of Charlottenburg. He was the second Engineer to become a Member of the French Academy of Science.

At the moment of going to press we learn with regret of the death last Saturday of Mr. J. G. W. ALDRIDGE, the Chairman of Messrs. Aldridge & Ranken, Ltd., at his residence, "Bracondale," Worple Road, Wimbledon.

Mr. JOHN ROBINSON, formerly Representative of Messrs. Sawer & Purves, of Manchester, died on Jan. 13 at Grasmere. He was Northern Representative of the firm for thirty years, and retired five years ago. He was particularly well known to the gas industry in Lancashire and the Newcastle district, where his genial disposition attracted a host of friends.

The American gas industry have lost a genial friend and sympathetic counsellor in the passing of Mr. GEORGE G. RAMSDELL at the age of 81 years. Born in Providence, R.I., he undertook to organize a company to heat Vincennes from a central plant at the conclusion of his universtiy career. In 1890, he became General Manager of the American Gas Company, Philadelphia. Fifteen years later he became President of the Ramsdell Inverted Gas Lamp Company, while in 1911 he was elected Secretary and Treasurer of the American Gas Institute. He was a member of the headquarters staff of the American Gas Association since its formation. With 52 years of continuous service in the gas industry to his credit, Mr. Ramsdell had his wish gratified. This wish, as he himself expressed it, was "to die in harness."

National Gas Council.

Meeting of Central Executive Board.

The Central Executive Board of the National Gas Council held their first meeting of the year at the Savoy Hotel, Strand, on Jan. 14, following a luncheon given by the President (Sir David Milne-Watson) to the members of the Board.

Coal Mines Bill.—The Chairman stated that, in view of the speech which he had just made at the luncheon preceding the meeting, he did not propose to discuss the terms of the Bill, which were generally well-known.

Area Gas Supply Committee.—A meeting of the Area Gas Supply Sub-Committee of the National Gas Council held at Leeds on Jan. 3 was reported.

Committee of Inquiry into Finance and Industry.—Mr. Wm. Cash, speaking on behalf of the Committee appointed by the Board to give evidence before this Committee, stated that a Memorandum had been prepared of the points which might be included in the evidence; and an outline of these points was read and approved. It was added that the Federation of British Industries proposed to give evidence also, and had written to the Council asking whether the gas industry had any points which it was desired should be put forward by the Federation. The Central Executive Board authorized the Committee to confer with the Federation of British Industries in this matter.

"Northumberland" Clause.—With reference to the statement made at the previous meeting of the Board, that the Electricity Commissioners had made the Extension Order for which the Corporation of Great Yarmouth applied in 1928, and that the Order did not contain the "Northumberland" Clause, but cut down to small dimensions the extensive area for which the Corporation had applied, it was now reported that this small area was only given for the purpose of enabling the Corporation to supply electricity in bulk to two small towns—Bungay and Beccles—and that these towns had given a guarantee to the Corporation to defray any deficit which might arise out of the supply of electricity to them. Further, the Corporation had given an undertaking that in the unlikely event of the Corporation making a subsequent application for any part of the area originally included in the present Order, the "Northumberland" Clause would be incorporated in the necessary Order. In these circumstances it was considered unnecessary for the Council or for the Gas Company to oppose the confirmation of the Order by the Ministry of Transport.

Newport Corporation Bill.—Mr. J. H. Canning, on behalf of the Newport Gas Company, stated that the Bill which was being promoted this session by the Newport Corporation contained a clause regarding the reinstatement of roads, to which the Newport Gas Company objected. The Clause conferred upon the Corporation the exclusive right of filling in trenches and making good the surface of any street, and did not contain provision enabling the public utility undertakings of the area to take adequate steps to protect their pipes. Further, it was doubtful whether the liability imposed upon the Gas Company by the Gas-Works Clauses Act, in respect of streets which had been reinstated, was transferred to the Corporation. It was agreed that the Council should support the Gas Company should it be necessary to oppose the Bill in Parliament.

Income-Tax.—It was reported that the attention of the Council had been drawn to an interesting and difficult point in connection with a certain Gas Company which had entered into an agreement to take gas in bulk from a coke oven, and in virtue of that agreement had dismantled its works. The Company contended that its works had been replaced by the main connecting it with its source of supply—*i.e.*, the coke oven—and claimed that the cost of the main should be regarded as a replacement of plant and machinery for income-tax purposes. The local Inspector of Taxes resisted this contention, and maintained that a replacement could only be regarded as an allowable deduction for income-tax purposes in cases where the gas-works were replaced *in situ*. As this was a question which might be of importance in the future, it was agreed that the Council should take Council's Opinion on the point.

Glimpses into the Past.

From the "JOURNAL" Eighty Years Ago.

Gas Lighting in Italy.

It will appear incredible to an English reader that, in the year 1850, a well-constructed and economically-conducted gas-work—having the exclusive supply of a rich European capital, numbering more than 100,000 inhabitants, and enjoying thorough communication by water with our own coalfields—should have exhausted an ample capital, and be reduced to the necessity of discontinuing its operations. Had it been Rome, or Constantinople, or Athens, or some other venerated relic of departed greatness, the wonder would be less intense; but that Florence the Fair—once the cradle of the reviving arts, and now the treasury of their most glorious triumphs, the goal towards which every lover of them bends his steps, and quits with a sigh—should present us with such a spectacle, almost surpasses belief.

From a Meeting of the Marylebone Gas Consumers' Protection Committee.

Mr. SHIELD said he rose to propose an amendment. (Tremendous groans and uproar.)

The CHAIRMAN said the meeting had promised at the outset to support him in doing justice, and unless they heard Mr. Shield he must leave the Chair. (Cheers.)

Mr. SHIELD . . . began to read his amendment, which was expressing no confidence in the promoters of the Marylebone Gas Consumers' Company, but the Chairman stopped him.

Mr. LAWLEY . . . here came forward to address the meeting. (Cries of, "Are you a ratepayer?")

Mr. PEARSE: No.

This exclamation on the part of the unfortunate champion of the old gas companies, who had remained remarkably quiet until this moment, was the signal for a scene of the most ruffianly and disgraceful conduct on the part of the supporters of the new company ever witnessed in a public assembly of Englishmen, and, from the ferocious aspect of some of his assailants, anyone witnessing the scene might have supposed that "Lynch law" was about to be carried into effect on the person of the unfortunate Mr. Pearse. He was immediately seized by the collar, by several of the professed liberals of the new party in Marylebone, whilst a rush was made to the platform at him from the body of the meeting; the cries of "Police, police," resounded through the building. . . . Five or six policemen made their way to the scene of tumult, which, in consequence of the pressure, was in no small degree increased by the giving way of a portion of the platform. . . . The unfortunate gentleman was ultimately dragged like a felon out of the meeting, amidst the cheers and hisses of the contending parties.

The proceedings were resumed, and Mr. Lawley had just commenced his address to the meeting, when Mr. Pearse again made his appearance at an upper door, and rushed into the body of the meeting, followed by a host of his tormentors. He succeeded in reaching the midst of his friends, who surrounded him, and there were the strongest symptoms of a general pugilistic contest; the uproar being so intense that no business could be done.

The Chairman . . . quitted the Chair. . . . The Press followed the example of the Chairman, and quitted the disorderly scene.

Who Invented the Gas Cooker?

The following is an extract from a letter by Samuel Clegg: In the "Expositor" of last week, I saw a portrait of Mr. Sharp, the Manager of the Southampton Gas-Works, and an article claiming for him the invention of cooking by gas. Now, I do not believe any living man can claim it as his invention. In 1739 Dr. Clayton boiled eggs by a gas flame; in 1792 Mr. Murdock frequently cooked chops and steaks over gas jets; and, in 1824, I perfectly well remember the men at the Aetna Ironworks, near Liverpool, making a gas cooking apparatus, which consisted of a gun barrel turned backwards and forwards, and pierced with numerous small holes. When anything had to be fried the gridiron was kept in a horizontal position; when anything had to be roasted it was turned in a vertical position, and a plate of tin was placed behind the meat, as a reflector, or hastener, as I think the cook calls it. Mr. Sharp may have contrived a stove for cooking by gas—that is, pieces of iron so placed as to hold different things . . . but I believe that Mr. Alfred King, of Liverpool, arranged (I won't call it invented . . .) the first convenient apparatus for cooking by gas.

Topical Items.

Conference of Authorities on Street Subways for London.

A conference of authorities and bodies concerned in the provision of subways in London was held on Jan. 14 at the County Hall. The conference was convened by the London County Council on the recommendation of the General Purposes Committee after consideration of the report of the Commission of Inquiry into the Holborn Explosions and Fires.

The conference was attended, among others, by representatives of the Commercial Gas Company, the Gas Light and Coke Company, and the South Metropolitan Gas Company.

Mr. H. E. STILGOE, Chief Engineer of the Metropolitan Water Board, moved the following resolution: "While it is not practicable in the case of the majority of existing streets to incur the heavy expenditure which would be involved in the construction of subways thereunder, it is essential that in all new arterial roads or considerable widening or reconstruction of existing traffic arteries, new provision of subways should be made for the accommodation of pipes, sewers, &c." He said that the resolution was brought forward on the suggestion of the Metropolitan Water Board.

Mr. E. E. FINCH, representing the City of London, said that if there was to be any extension of pipe subways in London, it must be on the basis of greater co-operation between the local authorities and the statutory undertakings.

Mr. STEPHEN LACEY, of the Gas Light and Coke Company, said that the Company did not wish to lay gas mains in subways that might be constructed in the future. [We understand that the electricity supply undertakings take the same line in regard to high-tension cables.]

The resolution was eventually agreed to after the word "desirable" had been substituted for "essential."

It was also agreed that the Government should be asked to hold an inquiry into the London subway question.

Southport Plumbers Contest Gas Fittings Clause in Corporation Bill.

There was no doubt that if the private trader was to retain his interest in the trade of the country he would have to fight for it. On the one hand they had co-operative societies and on the other the Corporations. This was said by Mr. A. Eyres, President of the Southport and District Ironmongers' Association, in a vote of thanks to the deputation which had carried on negotiations with the Southport Corporation in connection with certain clauses respecting gas and smokeless fuel appliance fitting in the Corporation Bill now before Parliament.

The Ironmongers' Association, it was reported, had gone into the provisions of the Bill, and drew the attention of the Plumbers' Association to one or two contentious passages. The Plumbers' Association called a joint meeting, and as a deputation met the Corporation Parliamentary Committee on three occasions, and as a result of the discussions a compromise was arrived at. Sub-clause (1) of Clause 13 was deleted, and the following sub-clause substituted:

> The Corporation may purchase, sell, or let for hire (but not manufacture) gas engines, gas stoves, gas ranges, and other gas fittings for lighting, motive, heating, ventilating, or cooking, and any other purposes, and stoves, fires, and furnaces for consuming coke or smokeless fuel (all of which are in this section called "fittings") and may fix, repair, maintain, or remove any such fittings as have been let by them on hire, or sold on hire purchase, and may provide all materials and do all work necessary and proper in that behalf and, with respect thereto, may demand and take such remuneration, or rents, and charges, and may make such terms and conditions as may be agreed upon.
>
> Provided that nothing herein shall authorize the Corporation to fix, repair, or maintain tiles, or mantelpieces, or stoves, fires, and furnaces for cooking purposes, or any pipes or apapratus (other than flue outlets) by which the heat from any fittings for the consumption of coke, or smokeless fuel, is transmitted by water, air, or other means.

A covering letter from the Town Clerk stated that there was no intention on the part of the Gas Committee to depart from its present practice of working in co-operation with the two Associations with regard to the installation of cookers and fires, which practice it proposed to continue on the understanding that it would be carried out satisfactorily as it had been in the past.

Woodall-Duckham Work in 1929.

A Year of Great Progress.

The year 1929 has been one of great importance to the Woodall-Duckham Company, for it has marked the bringing into successful operation of a number of new ventures. As far back as 1921, the Directors of this enterprising Company, under the leadership of Sir Arthur Duckham, G.B.E., K.C.B., decided that they must broaden the scope of their activities if they were to have a progressive business. They therefore planned a campaign of development work. They studied carbonization practice in America, Germany, and France, and as the result of these activities, made available for the British carbonizing industries a number of carbonizing processes.

The variety of the plants put into operation during 1929 by this Company is the best comment on the success of the development policy.

Thirteen new installations of "W.-D." continuous vertical retorts have been put into operation. These include two large installations of 103-in. retorts at Glasgow and London, and other continuous vertical retort plants at Cleethorpes, Crieff, Gorleston, Hereford, Otley, Quebec, Silsden, Spalding, Tredegar, Valparaiso, and Wellington. Three installations of intermittent vertical chambers have been started up—one at the Dawsholm Works, Glasgow, consisting of 48 chambers; one at Croydon, comprising 36 chambers; and a second installation at Ramsgate.

Two large Becker coke oven plants have been put to work—one at Thorncliffe consisting of 59 Becker ovens and carbonizing over 1200 tons of coal per day. This plant supplies surplus gas to the Sheffield Gas Company. The second plant—at Bedwas, South Wales—consists of 35 ovens. Both these plants are provided with bye-product recovery plants. In connection with the coke oven plant at Bedwas, a dry coal cleaning plant on the Peale-Davis system has successfully been put into operation.

The first Woodall-Duckham continuous circular tunnel kiln has attained success after a long period of development, and, of 3 new kilns on order, one has been started up at the works of Messrs. Doultons. The "W.-D." refuse destructor plant at Huddersfield is working satisfactorily, while "T.I.C." tar treatment plants have been installed at Fleetwood and Esbjerg, and two have been shipped to New Zealand.

Labour Opposition to Glasgow Corporation Provisional Order.

The National Union of General and Municipal Workers in their official journal state that the union M.P.s have been requested to "block" the Glasgow Corporation Provisional Order because of Clause 55, which empowers the Corporation to make contracts with outside companies for the supply of gas in large quantities.

The action is being taken as a protest against the Corporation decision favouring the Gardner Gas Contract, which, it is alleged, will displace several hundred municipal workers when it becomes fully operative. The union M.P.s include Mr. J. R. Clynes (the Home Secretary), Mr. Will Thorne, Mr. Jack Jones, Mr. Charles Dukes, and Mr. Arthur Hayday.

Mr. F. Blackburn, of Plymouth, Discusses the Present Position of the Gas Industry.

The "Gas Industry" was a subject of an address by Mr. F. BLACKBURN, the City of Plymouth Gas Engineer, to the members of the Plymouth Rotary Club on Friday, Jan. 17.

Mr. Blackburn said that the City of Plymouth Gas Department, supplying the Devonport area of the city, carbonized some 42,000 tons of coal and gasified 350,000 gallons of gas oil last year, manufactured 900 million c.ft. of gas, supplied the tar distillery at Cattedown with 360,000 gallons of crude tar, sold 12,000 tons of smokeless fuel in the form of coke for domestic and industrial purposes, and supplied some 300 tons of sulphate of ammonia to the farmers of Devon and Cornwall. The output of gas from the works was increasing annually, which showed that gas was still the most satisfactory source of heat, light, and power.

It was surprising that in the last five years, in spite of the rapid growth of electricity under national protection and stimulation, the rate of growth of the gas industry had been 50 p.ct. faster, or for every two extra units delivered to the consumers by the electrician the gas engineer had been called upon to

deliver three. The gas cooker was accepted as the most economical and hygienic method of food preparation, and it was estimated that about 90 p.ct. of the dinners eaten in this country were cooked with its aid. The simplicity of cooking by gas reduced the servant problem to a minimum, and mere man was placed in an independent position where necessary.

Present atmospheric conditions in cities and towns were bad enough, but they would be too dreadful to contemplate if the gas industry were to be closed down. Doctors and statisticians had given careful thought to estimating the damage done to health and property by the smoke curse, and the figures were appalling, not only in millions of pounds sterling, but in mortality, impairment of health, and in lessened working capacity of the nation. It could be said for Plymouth that the bulk of the new houses built by the Corporation had been equiped with gas fires, gas coppers, and gas cookers, and should more gas fires be used the soot which fell about the streets and buildings would rapidly disappear.

He was in no way trying to depreciate the services rendered by the electrical industry, but only to correct the one-sided and exaggerated assertions of some of its over-zealous enthusiasts, which might have an unfair effect upon public opinion to the detriment of an equally important and far larger public service.

On Scientific Writing.

Edwin E. Slosson has the following to say on scientific writing in a recent number of "Science:"

Since it has been my lot for many years to earn my living by translating scientific literature into the vulgar tongue, I have often wondered why the writers made it such hard work to read the original language. If the difficulty were due to the profundity of the thought or complexity of the reasoning, then it could not be avoided. But I have found that important papers by the deepest thinkers were apt to be easier to follow than those by minor men dealing with comparatively trivial topics.

Nor does the cause of the obscurity lie, as is commonly said, in the use of technical terms. The sports section or fashion page of a newspaper has as specialized a vocabulary as a scientific paper. Many scientists do, indeed, employ technical language unnecessarily in writing for the outside public, but even where the words are all familiar the meaning may still be obscure.

I have come to the conclusion that the chief reason why scientific literature offers such high resistance to reading is the use of the alternating current instead of the direct in conveying the thought. The writer interposes a negative every few words that reverses the meaning of the sentence. This keeps the reader on the jump.

The asymptotic ideal toward which scientific writing tends is a sentence structure something like this:

> The present writer is indisposed to deny that he is unconvinced of the necessity of refusing to accept the infrequency of negative reactions as a not insuperable argument in disproof of the theory.

Such sentences may be quite logical and free from technical terms. They can be disentangled in time, and when straightened out the meaning may turn out to be something simpler than it sounds. But they are constructed like the Chinese boxes. When you get one opened you come on to another. The process of extracting the meaning is like the simplification of a complicated algebraic equation, and in extricating the internested parentheses you are likely to come out with the *plus* and *minus* signs mixed.

History of Industries but a Progression from Gas to Gas.

Given a certain amount of poetic license (said Mr. R. Robertson, Engineer to the Bristol Gas Company, before the Bristol Rotary Club on Jan. 13), the gas industry may be regarded as the first and the last of industries, for the first nebulous manifestations of Nature were evolved from gas, and the Smoke of Judgment Day implies the resolution of all things into gas again; so that the history of all other industries is but an interlude or a progression *from* gas *to* gas.

Gas was introduced to Bristol in 1811 by John Breilatt, a dyer in Broadmead, who lit his house and shop with the new illuminant. He also gave lectures and demonstrations on the subject to the public, and a movement to form a gas company followed.

First attempts, according to Matthews, "met with the opposition which prejudiced and ignorant minds generally give to improvements," and the promoters had to limit their profits to 10 p.ct. in order to "silence a most indecent clamour from the parochial vestry," who opposed their application for an Act of Parliament. The Act was duly obtained, and the Bristol Gas Light Company was formed in 1816 with a capital of £5000. The site chosen for the first works was at Temple Backs, but the Bristol Court of Aldermen "considered it their bounden duty to withhold permission for the erection of a gasholder because it would endanger the City Gunpowder magazine at Tower Haritz" near by. This opposition was, however, withdrawn, and no catastrophe occurred; but two years later the works were removed to the present site in Avon Street.

A Rival Company.

In 1823, another Company called the Bristol and Clifton Oil Gas Company was formed to manufacture oil gas at Canon's Marsh. Competition between the rival Companies was very keen and continued until 1853, when they amalgamated under the name of "The Bristol United Gas Light Company," subsequently altered to "The Bristol Gas Company" in 1891.

The Stapleton Road Works were started in 1879.

The Bristol Undertaking ranks tenth in order of size, and great progress has been made during the last 75 years. Gas sold last year amounted to 4000 million c.ft., an increase over the previous year of 166 million c.ft.—equal to twice the total annual consumption of Clevedon—indicating that the industry is neither dead nor dying.

Just as in the cosmic order we have seen that gas is first and last, so in the life of the individual it is first and last, for it may truly be said that from the cradle to the grave or, more literally, from the incubator to the crematorium—for gas is used for both—there is no purpose for which man requires light, heat, or power which could not be accomplished efficiently and economically by gas.

Replying to a question, Mr. Robertson said the coal in the Somersetshire coalfield compared very favourably with coal from other centres for gas making purposes. This coal, however, was not so good as the coal from the Midlands, as the ash content was rather high; but this was the only drawback with local coal.

Gas Purification at Elevated Pressure Discussed by Coke Oven Managers.

In his inaugural address as Chairman of the Midland Section of the Coke Oven Managers' Association, Mr. G. T. Purves, M.I.Chem.E., Assoc.M.Inst.C.E., said that, now an increasing amount of gas at elevated pressure was being delivered from coking plants, it seemed proper that all the purification of gas on coking plants should be carried out under pressure, since the gas in any case had to be compressed. In purification under pressure the saturators would require to be placed on the suction side of the exhausters if either the direct or semi-direct processes were used. But the effect of pressure on the solubility of ammonia, carbon dioxide, and sulphuretted hydrogen was so great that the old indirect process might be the most suitable. Further, the ammonia liquor could be easily worked up to such a strength as would justify the transit of the same from a number of plants to a central station of large size, where, by using gypsum or anhydrite, very economic production of sulphate of ammonia could be effected. Now that synthetic sulphate of ammonia had so seriously reduced the margin of profit, such central plants were worth very serious thought.

When they considered benzole recovery, the value of high-pressure working became even more apparent. It had long been recognized that the present oil-washing process left much to be desired. Not only was the saturation of the washing oil low, but the magnitude and cost of the plant involved in benzole recovery and refining, were, relative to the other processes, excessively great. Where gas was not required under elevated pressure, it could, following the purification process, be expanded on the same shaft as the compressors, so returning much of its energy, and the cooling effect so produced used in the benzole washing process. The compressed gas, after benzole recovery, could be washed with water for the removal of carbon dioxide and sulphuretted hydrogen, and the energy of the water given up on the same shaft as the water pump. The gas liberated from the water could then be passed through oxide of iron purifiers just as was done in the Petit process. This was one of the standard methods used to-day for removing carbon dioxide from gaseous mixtures.

In this country the drying of the gas prior to distribution was effected by washing with calcium chloride or glycerine at low pressure; but in Germany this was being done by cooling after compression, and naphthalene was also being removed under pressure by oil washing. These developments seemed to indicate a natural tendency towards pressure purification. With the idea of a gas grid so far developed in this country, and the probability of the reconstruction of the coking plants so near at hand, this did seem the time for serious consideration of purification methods. High pressure was used by Claude in the preliminary purification of the gas before separation of hydrogen according to his system, and the plant involved was relatively small and very efficient. There was nothing new in high-pressure purification, but it had not yet been employed on coking plants.

Commercial and Industrial.

Stock Market Report.

[For Stock and Share List, see later page.]

The Gas Stock and Share Market diplayed a somewhat more cheerful tone last week. Prices are slowly but steadily on the increase; and though there is a tendency towards appreciation at this time of year on account of the forthcoming dividend disbursements, there is no doubt that a quiet optimism is prevalent generally.

Judging by reports, many investors appear to be concentrating on gilt-edged securities with a steady 5 p.ct. investment yield. The ordinary stocks, however, of most of the home gas companies, at present prices, show a return of over 6 p.ct., together with first-class security. Among these companies are the following:

—	Present Price.	Dividend. Year 1928. P.Ct.	Yield P.Ct. per Annum.
			£ s. d.
Aldershot 5 p.ct. maximum	72½	5	6 17 11
Bournemouth 5 p.ct.	133/4	8¾	6 12 0
Brighton and Hove 6 p.ct.	114½	7½	6 11 0
" " " 5 p.ct.	101½	6¾	6 13 0
Chester 5 p.ct.	92½*	5¾	6 4 4
Commercial	92½	6	6 9 8
Croydon sliding scale	105½	7	6 12 8
Gas Light and Coke	18s. 6d.	£5 11s.	6 0 0
Hastings and St. Leonards 5 p.ct.	100½	7	6 19 3
" " " " 3½ p.ct.	79½	5½	6 18 4
Hornsey Cons.	85½	5¾	6 14 6
Liverpool 5 p.ct.	91½*	6	6 11 1
Newcastle and Gateshead Cons.	16s.	£5 3s. 9d.	6 9 9
Portsmouth Cons.	115½	8	6 18 6
Sheffield Cons.	105†	6½	6 3 9
South Metropolitan	100	6½	6 5 0
South Suburban 5 p.ct.	102½	6½	6 6 9
Southampton 5 p.ct.	78½	5	6 7 4
Uxbridge 5 p.ct.	99½	£6 18s. 9d.	6 19 6

* On the Liverpool Exchange.
† On the Sheffield Exchange.

At the time of writing all the above stocks are full of dividend and are undoubtedly undervalued.

Price changes last week were as follows:

Rises: Bournemouth 6 p.ct. pref., ⅜ to 10⅞-11⅜; Bristol 5 p.ct. max., ⅛ to 86-87; Chester 5 p.ct. ord., 3 to 90-95; European, ½ to 13-15; Gas Light ord., 1½d. to 18s. 3d.-18s. 9d., 4 p.ct. pref., 1 to 76½-77½; Imperial Continental, 5 to 350-370; Montevideo, 2 to 107-112; Primitiva ord., 6d. to 28s. 6d.-30s. 6d.; San Paulo 6 p.ct. pref., ⅛ to 8⅝-9¼. *Fall:* Colonial ord., 2s. to 21s. 6d.-23s. 6d.

Coal Markets.

From all markets quiet trading is reported, with no particular features. On the North-East Coast, Northumberland steams are outstanding, D.C.B. qualities being firm at 17s. f.o.b. Gas coal producers are not being pressed for prompt supplies, but the better qualities have reasonably good stems. Wear specials are quoted at 17s. 6d. f.o.b., with best qualities at 16s. 9d., and seconds 15s. 6d. to 15s. 9d. Several small inquiries from Continental gas-works are circulating for later in the year, but generally speaking forward business is difficult to arrange. The conversations which have been taking place between English and Polish coalowners, the outcome of which is at present unknown, are adding to the general uncertainty of the situation due to the forthcoming legislation. In the Yorkshire section, gas coals are also quiet, but prices are quoted at about the previous levels of 18s. to 18s. 6d. f.o.b. for screened, 18s. for washed trebles, 17s. 3d. to 17s. 9d. for washed doubles, and 16s. to 16s. 6d. for washed singles.

The demand for gas coke is good, and f.o.b. or delivered values are 25s. to 26s. in all markets.

Overseas Opportunities.

[From the Board of Trade Journal.]

South Africa.

Producer-Gas Plants (Using Coke), Wood-Working Machinery, and Other Industrial Machinery.—A firm of manufacturers' agents in Cape Town desire to undertake the representation, on a commission basis, of British manufacturers of the above for the Western Province. (Ref. No. 63.)

Contracts Open.

Purifiers, &c.

The Rawmarsh Urban District Council invite tenders for the supply and erection of two cast-iron purifiers, &c. [See advert. on p. 218.]

Retorts.

The Loughborough Corporation Gas Department invite tenders for the renewal of retorts. [See advert. on p. 218.]

Tar.

The Slough Gas and Coke Company invite tenders for their surplus tar. [See advert. on p. 218.]

Current Sales of Gas Products.

The London Market for Tar, Tar Products, and Sulphate.

LONDON, *Jan.* 20.

There are no changes to report in the prices of tar products.

Creosote for export is 6¼d. to 6½d. per gallon f.o.b.

Pitch is 47s. 6d. per ton f.o.b.

Pure toluole is 2s. 5d. to 2s. 6d.; 95/160 solvent naphtha, about 1s. 5d.; pure benzole, about 1s. 11d.; and pyridine bases, about 3s. 9d. all per gallon.

Tar Products in the Provinces.

Jan. 20.

The average prices of gas-works products during the week were: Gas-works tar, 25s. to 30s. Pitch—East Coast, 47s. 6d. f.o.b. West Coast (f.a.s.) Manchester, 42s. to 42s. 6d.; Liverpool, 45s. 6d. to 46s. 6d.; Clyde, 45s. 6d. to 46s. 6d. Toluole, naked, North, 1s. 7¼d. to 1s. 8½d. Coal-tar crude naphtha, in bulk, North, 9d. to 10d. Solvent naphtha, naked, North, 1s. 3d. to 1s. 3½d. Heavy naphtha, North, 1s. to 1s. 0½d. Creosote, in bulk, North, liquid and salty, 3½d. to 3¾d.; low gravity, 2d. to 2¼d.; Scotland, 3¼d. to 3¾d. Heavy oils, in bulk, North, 5¼d. to 6d. Carbolic acid, 60's, 2s. 4d. to 2s. 6d. prompt. Naphthalene, £12 to £14. Salts, £5 to £5 10s., bags included. Anthracene, "A" quality, 2½d. per minimum 40 p.ct., purely nominal; "B" quality, unsaleable.

Tar Products in Scotland.

GLASGOW, *Jan.* 18.

There has been no great change in market conditions throughout the week. Solvent naphtha and benzole are accumulating in this area, and inquiries are scarce.

Pitch continues nominal at 47s. 6d. to 50s. per ton f.a.s. Glasgow for export, with a premium of about 5s. per ton for home trade.

Tar is still commanding considerable attention, and value is steady at about 4d. to 4½d. per gallon in buyers' packages at works.

Creosote.—Some home orders have been placed during the week; but prices are unaltered at 3¾d. to 4⅛d. per gallon for B.E.S.A. specification, 3½d. to 3⅝d. per gallon for light oil,* and 3d. to 3½d. per gallon for neutral oil, all free on rails in buyers' tanks.

Cresylic.—The market continues easy. Pale 97/99 p.ct. is 1s. 9½d. to 1s. 10¼d. per gallon; dark 97/99 p.ct., 1s. 7⅞d. to 1s. 8⅜d. per gallon; pale 99/100 p.ct., 2s. 0½d. to 2s. 1½d. per gallon; high boiling, 1s. 10d. to 1s. 11d. per gallon, all *ex* works naked.

Crude Naphtha.—The value is nominal at about 5½d. to 6d. per gallon free on rails-works.

Solvent naphtha is weak, and orders are scarce; 90/160 grade is 1s. 1d. to 1s. 2d. per gallon, and 90/190, 11½d. to 1s. per gallon.

Motor benzole continues quiet at 1s. 5d. to 1s. 5½d. per gallon.

Pyridine is 3s. 3d. to 3s. 6d. per gallon for 90/160 quality, and heavier grades remain unsaleable meantime.

* "Light oil" and "crude naphtha" are now considered synonymous. In our Scottish report under creosote the term "light oil" refers to light creosote oil. In future this will be called "low gravity" to avoid confusion.

Benzole Prices.

The following are considered to be the market prices to-day:

	s. d.	s. d.	
Crude benzole	0 10	to 0 11	per gallon at works
Motor "	1 5	" 1 6	" " "
90 p.ct. "	1 7	" 1 8	" " "
Pure "	1 10	" 1 11	" " "

Trade Notes.

Purifier Extensions at Preston.

The Preston Gas Company have placed an order with Messrs. Broadhead Constructions, Ltd., of Stretford, Manchester, for extensions to the purifiers which this firm have previously installed, at the new Lostock Hall Gas-Works.

Sulphate of Ammonia Plant Extensions at Bradford.

The Bradford Corporation Gas Committee have accepted the offer of Potts, Cassels, & Williamson, Ltd., of Glasgow, for the supply of renewals for the sulphate of ammonia hydro-extractor at the Frizinghall Chemical Works.

Retort Extensions at Portland.

The existing retort bench at the Portland Gas Department works is being extended by Messrs. Robert Dempster & Sons, Ltd., of Elland, with modernized settings comprising the non-clinkering screen-bar grate, and the firm's patent flat deadweight bench cover in place of the existing main arch.

The "Salermo" Process of Coal Distillation.

From Salermo, Ltd., of 14, Waterloo Place, S.W. 1, we have received their latest brochure on the subject of their "Salermo" process of low-temperature distillation of coal. This publication deals in a very detailed manner with all the phases of this plant's operation, with comprehensive tables and diagrams of working results and sectional views of the retort. The purpose of the brochure is to give an account of the "Salermo" plant and its performance on different kinds of carbonaceous materials, and of the yields, properties, and uses of the products obtained, based on actual tests.

Notes on New Books.

SPECIFICATIONS FOR BENZOLE.*

Reviewed by Dr. W. B. DAVIDSON.

Recognizing the value of the publication of definite standard specification for benzole and allied products, the National Benzole Association have recently published a small volume of 145 pages which describes all that the manufacturer, buyer, and analyst require to know regarding different grades of benzole, toluole, xylole, and coal tar naphtha. For the compilation of the specification the Association secured the collaboration of representatives of the gas, coke oven, and tar distillation industries, together with three independent chemists. The result is most praiseworthy in its lucidity, style, and completeness.

Acknowledgment is made to the Standardization of Tar Products Tests Committee (their recent publication was reviewed in the "JOURNAL" for Jan. 8, p. 86), whose methods of testing, as applying to benzole and allied products, have been embodied in the volume under review.

Thus, there is not much that is new or original in the book now published, and, further, owing to the printing and figures or diagrams occupying only one side of a leaf, for the major part of the book, the text is unusually widespread, making for great comfort and easy reference, but disappointment as regards new information.

Part I. deals with definitions, abbreviations, specifications (arranged nicely in page form) for pure benzole, pure benzole for nitration, motor benzole, 90's benzole, 90's benzole for colour manufacturers, and so forth, for the various other products above mentioned. Provision is made by means of spare blank leaves for the insertion of further specifications that may be issued later. Printing, paper, and binding are first class, leaving nothing to be desired, and the Secretary is to be congratulated on the production.

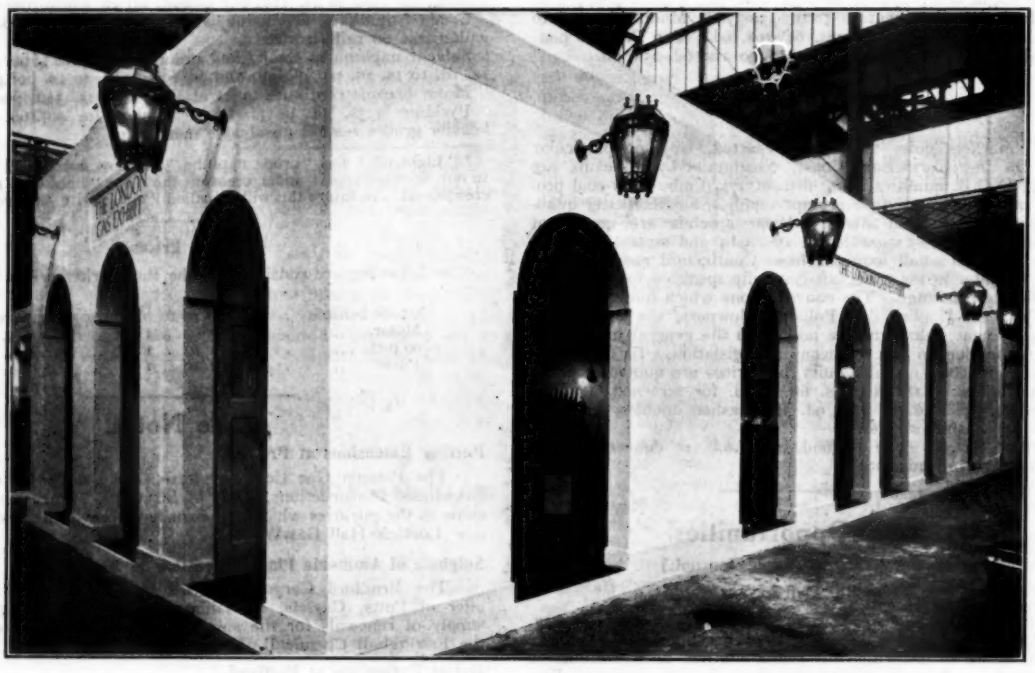
* "The National Benzole Association. Standard Specifications for Benzole and Allied Products, 1929." Published by the National Benzole Association, Wellington House, Buckingham Gate, London, S.W. 1 (Copyright). Price, 6s. net.

Olympia Shows Value of Gas to Nation's Health.

The nation's health depends primarily on good food well cooked, and there has been ample evidence at Olympia this month that "gas for cooking" is an almost universal health-preserver. Gas is prominent throughout all the sections of the Cookery and Food Exhibition which commenced on Jan. 14 and closes on Jan. 25. Chefs from many countries are jointly demonstrating their own skill and the magic of gas, for in the lecture theatres, which are thronged daily, gas only is the cooking agent.

The gas undertakings represented are the Commercial, Croydon, Gas Light and Coke, South Metropolitan, South Suburban, Tottenham and District, and Wandsworth, Wimbledon, and Epsom; and the exhibit reflects great credit on those responsible, and we may be pardoned for mentioning by name the Hon. Secretary of the Committee, Mr. J. E. Henwood, who has done such good work for the cause of both gas and the exhibition generally.

The Gas Display is of semi-open style, and enables visitors to gain at a glance a favourable impression of the cleanliness,



THE LONDON GAS EXHIBIT.

As is usual at this annual exhibition, which yearly becomes more popular, several cooking contests are being held, and here again gas holds sway. Among these contests, a prize competition organized by the London Gas Exhibit Committee proved a great success. It was divided into two sections—one for children under 14 years of age, and one for adults and children over 14 years. Competitors had the choice of making a fruit cake, a madeira cake, or gingerbread (prepared in gas ovens); and there were substantial awards.

The Exhibit Committee have an extensive and attractive display, as can be seen from the accompanying illustrations. comfort, and artistic merit of gas lighting, heating, water-heating, and cooking. The illumination of the stand is beyond criticism, and the different gas appliances are shown in operation to the best possible advantage. Different sections of this architectural display demonstrate a model kitchen, a bathroom, and a study; restaurant and hotel equipment is separately exhibited, and literature on the virtues of gas is neatly arranged in a department to itself. No good purpose could be served by detailing the appliances shown, though we may mention that a new gas central heating unit is attracting much attention.

THE LOUNGE OF THE LONDON GAS EXHIBIT AT OLYMPIA

On the stands of no fewer than 36 firms gas apparatus is displayed, and the Joint Gas Exhibit Committee have a separate exhibit of gas-fired fish frying ranges in the "fish section." Here competitions have taken place in conjunction with the British Trawlers' Federation; and the stand is a centre of interest.

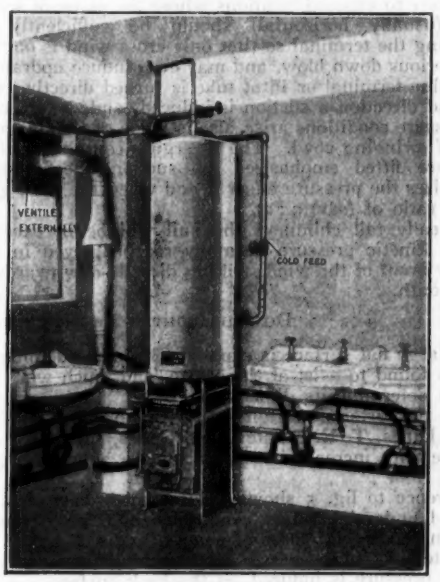
Gas Water Heating at Olympia.

Illustrated here is a "Victor" complete apparatus of the rectangular type (manufactured by Messrs. Thomas Potterton, Ltd.) fitted with a new "snap-action" positive-control thermostat, which has the advantage of extinguishing the gas at the burner, leaving only the pilot jet for re-ignition automatically when the water cools. The storage cylinder is insulated in a very effective manner, finished with enamel or cellulose in colour to choice.

This innovation renders the apparatus suitable for installation in any building where it is required to be left unattended day by day; the thermostat being such that it opens up whenever water is drawn, thus replenishing the supply as occasion may demand, without attention. This type of "Victor" apparatus is constructed with separate boiler and storage, so that the cylinder (or tank) is uninfluenced by the products of combustion.

A further advantage of the system of separate boiler and storage lies in the convenience of obtaining a small quantity of hot water quickly. The boiler unit, being separate, and connected to the cylinder (or tank), with flow and return pipes, delivers the high-temperature water the "Victor" boiler circulates to the top of the storage, and is immediately available at the taps.

"Victor" complete apparatus with rectangular storages are suitable for buildings of two storeys, being tested to 30 ft. head of water; and for high buildings "Victor" complete apparatus with cylinders of the standard type are available.



Messrs. Potterton have just completed the first portion of the new lavatory equipment in the extension of Olympia, where eleven complete installations of gas-heated hot water supply apparatus for the various lavatory blocks are being fitted. Each lavatory has a series of about eleven hand basins situated in different parts of the building on the various floors, and for each suite a "Victor" complete apparatus No. 193, having insulated storage cylinder of 35 gallons capacity, is provided. The storage is of special construction tested to 75 lbs. pressure, equal to 150 ft. head (nominal).

This is the third installation of "Victor" boilers adopted at Olympia during the past ten years, and in this particlar section gas is used exclusively for hot water supply.

Combustion, Wind, and Flue Equipment.

By C. A. MASTERMAN, B.A., A.I.C., of the Gas Light and Coke Company.

[From a Paper before the Institution of Heating and Ventilating Engineers, Jan. 8.]

(*Concluded from p.* 156.)

SECTION 7.

WIND AND PRESSURE LOSS AT OUTLET.

The resistance of the flue, R, may be divided into three quantities, X, Y, and Z, corresponding to loss at exit, in flue, and at entry.

In still air the pressure loss at the flue outlet will depend upon the type of terminal used. In general, it may be expressed in terms of equivalent length of straight flue pipe which will give the same resistance under the same conditions. Tests show the resistance of normal cone caps and cowls to be about the same as straight lengths of flue fifty diameters in length, but special terminals may reach values of twice this amount.

If the terminal is of the chimney pot type which restricts the flue area it may be more convenient to take this restriction as the significant area of the flue, in which case the resistance of the wider flue proper may usually be disregarded. (Heat losses from the larger surface may, however, be of some moment, although the construction will then in general be of brick.) The use of a chimney pot or other restriction is definitely to be recommended when venting into an old flue—the dimensions of which are in excess of requirements—since it prevents loss of pull owing to syphoning of cold external air down the flue.

WIND.

In practice, flues unfortunately do not operate in still air. Wind effects can be most troublesome, and for proper appreciation may conveniently be divided into two varieties, direct and indirect.

DOWN BLOW.

Direct down blow or kinetic pressure due to wind is associated with flues terminating in exposed positions. The pressure which can be induced by a wind blowing normally onto an open end finds its parallel in the Pitot tube. This effect alone should not generally be troublesome since it belongs exclusively to exposed positions where the plane of wind movement (usually horizontal) should be sufficiently obvious. Arranging the terminal so that only cross wind is obtained will avoid serious down blow, and may even induce updraught.

If a flue terminal or Pitot tube is turned directly away from the wind direction a suction is induced, and, where complicating pressure conditions arise, use is made of this in the various types of swinging cowl. The diverging cone head with which these are fitted emphasizes the suction effect, but it also emphasizes the pressure effect if and when the cowl gets stuck (in the ratio of (say) 3 : 2).

On really tall chimneys the pull will be in excess of the highest kinetic pressure normally reached, even in the most unlikely event of the wind striking directly downwards into the open mouth.

DOWNDRAUGHT.

If a large flat surface is exposed to wind, a definite pressure effect is found to exist at the centre, and much work has been done to determine its dimensions.

Tests on surfaces at right angles to the wind by M. Eiffel, W. H. Dines, T. E. Stanton, and others, show an increase in pressure with increase in size of surface approaching a maximum.

Reference to fig. 5 shows values which have actually been obtained under laboratory conditions, and the pressure effects noted in the special cases of shapes A and B are of considerable interest. It is seen that by opening the annular of B a greater pressure is induced on the back surface.

Assuming the momentum of the moving air to be entirely destroyed, a pressure per unit area of

Momentum × Velocity

would be expected. This is more than is obtained on the flat plates and in case B, but less than the special condition, A. This latter case involves some reversal of direction of flow such as occurs when a jet of water strikes into a hemispherical cup. If reversal was complete, the reaction and therefore the pressure would be doubled.

In so far as the pressure is more accurately a pressure difference as between the air at the flue terminal and the air in the boiler room, any suction effect on the latter, due to wind, will contribute to the downdraught effect. Such suction is frequently found to exist on the face of a building opposite to that against which the wind is striking. For this reason, the window ventilation of the boiler room should if possible be arranged on the same side of the building as the flue terminal. If, as sometimes happens owing to the presence of large buildings, &c., this static presure due to wind exists with the absence of air movement on the terminal, little can be done to diminish downdraught, if the pressure exceeds the

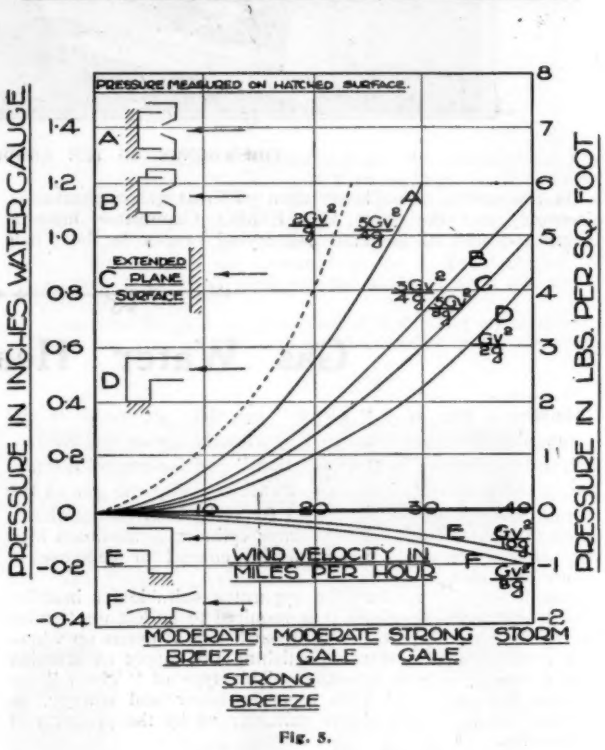


Fig. 5.

available pull, short of running a large inlet duct between the boiler grate and this terminal position.

SPECIAL TERMINALS.

Fortunately, air movement is not usually completely absent, and the energy associated with it may be used to offset in some degree the static pressure, and so help the pull.

The swinging cowl has been mentioned as one type of special terminal used for this purpose. An alternative type, of which various forms are available, is stationary, and depends upon special shaping of the louvres or other surfaces to deflect wind movement through the terminal in a direction helpful to removal of products.

F, in fig. 5, represents a section of a special terminal which has been found useful when positioned flat on an exposed wall. The wall itself deflects the wind locally into a direction parallel with its face so that air movement is across and through the "Venturi" section, inducing a low pressure point at the centre.

Special terminals of correct design will show a reduced downdraught effect with usually a higher resistance than normal terminals and chimney pots. The sum effect is to maintain a more nearly constant draught condition which is a valuable feature on boilers which will receive but little skilled attention.

For all terminals static pressure conditions must be avoided as far as possible, and the most exposed terminal position will in general be the best. If it is necessary to terminate below roof level, pockets of dead air such as occur immediately under eaves or against architectural features should be avoided.

A few inches shift of the terminal from the "wind shadow" of some projection may transform an installation.

DOWNDRAUGHT DEFLECTION.

The necessity for removal of the products of combustion from the boiler room has been mentioned, together with the special case of coal gas—the products from which should be quite innocuous. It is possible then with this fuel to accept downdraught as unavoidable, and to use a special fitting which will bye-pass the products into the boiler room (see fig. 6).

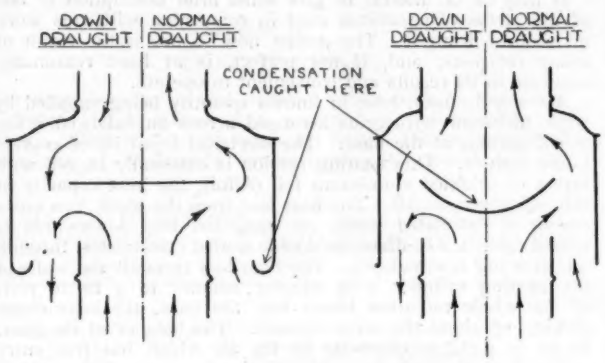


Fig. 6.

This downdraught deflector or baffler must be of correct design, so that there is no tendency during downdraught to force the products back onto the burner since carbon monoxide will otherwise be formed in abundance to the danger of anyone entering the boiler room. Unless it is of special design making the use of this fitting impossible, no gas boiler should be fixed without a baffler, which has the additional advantage of so isolating the boiler draught from the flue draught that the former can be and is permanently established to render the maximum thermal efficiency.

SECTION 8.

PRESSURE LOSS IN FLUE.

Expressions of varying degree of accuracy are available for the determination of the pressure loss in the flue or chimney. It is clear that in normal flues turbulent flow conditions will obtain, but D'Arcy's expression for the flow of gas through pipes leaves in doubt the value to be assigned to the coefficient of friction. Dr. Lees,[1] following up the work of T. E. Stanton and J. R. Pannel,[2] proposed an expression for flow inclusive of this coefficient, and it is a modification of this expression[3] which is here used. The matter is of some importance, since the change in viscosity of the flue gases with temperature has appreciable effect upon the pressure loss to be expected.

A full expression for resistance may then be derived by using an approximating relation for the kinematic viscosity.

Some legitimate simplification may be made by working always to a maximum value for the coefficient of friction ζ, the value of which, being qualified under a fifth root, will change relatively little. With 50 ft. of 4-in. flue at 400° Fahr. rise and velocity of products 10 ft. per second $\zeta = 0{\cdot}0103$. These are very pessimistic conditions and a value $\zeta = 0{\cdot}01$ gives a good margin for practical use. On a short wide flue where velocity is low the coefficient may be above this value, but the flue being short the absolute error will be small. With brick flues, where the friction effect will be higher than normal, the flue diameter will in general be reasonably large so that $\frac{WS}{A^2}$ will itself have a relatively low value which will compensate.

The resistance equation will then become

$$\text{Resistance} = \frac{0{\cdot}01 \times UWS}{64{\cdot}4A^2}$$

A = Cross sectional area in sq. ft.
S = Total surface of flue in sq. ft.
U = Velocity of flue gases in feet per second.
W = Weight of flue gases passed per second in lbs.
ζ = Coefficient of friction.

In addition to the resistance of the flue itself the effect of bends or elbows must also be considered. The dimension of this resistance increases with the sharpness of the bend and is normally at a maximum with an abrupt 90° elbow, amounting then to a resistance equivalent to a straight flue of over sixty diameters in length.

Since bends together with oblique or horizontal runs are often inevitable, although the latter are particularly undesirable, some allowance must be made for their resistance effect.

A mean figure of 10 diameters per bend on this account is considered reasonable. This appears to correspond to a smooth bend of one diameter radius.

SECTION 9.

COMBUSTION RATE AND PRESSURE LOSS AT INLET.

With any boiler and flue construction there will be a definite pressure loss or resistance associated with the inlet. This is most marked as a rule with solid fuel boilers where part, at least, of the air for combustion is drawn through the fuel bed, the amount controlling the rate of combustion. The resistance will obviously vary with the thickness of the bed and the type and grading of the fuel. Reference tables show the dimension of this pressure difference to be of the order of lbs. to the square foot and, for a given fuel, to be roughly proportional to the rate of combustion required per square foot of grate area.* Since boilers on central heating installations are usually only fired intermittently the air requirements are continually in a state of change. Any stationary draught control will at best be a compromise—the results of which will be sometimes excessive entry of air, sometimes inadequate air resulting in incomplete combustion. This unsatisfactory result is emphasized if the chimney is subject to varying wind pressures which lead to varying draught. It is for these reasons that a draught regulator is sometimes adopted in order to give some degree of automatic draught control thermostatically operated. The chimney draught is determined by the opening of a secondary port into the furnace or flue way while flow through the fuel bed itself is controlled by a damper on the air entry.

Somewhat similar considerations must apply to the use of oil as a fuel although here the combustion rate of the fuel is independent of the draught, wind effects only calling for a margin of pull above normal requirements.

In the case of normal gas-fired boilers, the presence of the baffler or draught deflector separates the flue equipment into two independent portions. The primary flue below the deflector is really an integral part of the boiler and should be of height balanced to give optimum boiler draught. The flue proper starts at the deflector and some slight resistance is inevitable at this point. Tests show this resistance to be equivalent to a straight length of about fifty diameters.

Excessive height of flue will merely draw in more air from the boiler room at the deflector, the influence on the boiler draught itself being negligible, while excessive wind pressure or downdraught will vent the combustion products into the boiler room.

SECTION 10.

CONDENSATION.

Throughout these considerations of flue equipment it has been assumed that the latent heat of water vapour in the combustion products has been completely lost. Some modern gas-fired boilers of special design work up to an efficiency approaching 100 p.ct. on the gross calorific value by recovering this heat (forced draught is then employed), but as yet these cases must be considered exceptional. It does, however, happen that condensation of some part of the water vapour may occur in the flue and this can be very troublesome. By concentration the condensation becomes definitely corrosive and damages the flue pipe material while, if excessive, it may run back to a horizontal joint where it will leak through to the outside of the pipe. Bafflers are usually designed to dispose of liquid condensation by re-evaporation from a dish or gutter (fig. 6), but the consequent gradual accumulation of solid deposits sets a limit to this solution of the nuisance. In order to deal with the small amounts of condensation which are almost unavoidable after first lighting up, when the whole flue is cold, asbestos cement which is absorbent gives good service. A brick flue might be expected to behave similarly but there is a tendency for the mortar to rot and swell after exposure to any considerable quantity of condensation so that there is much to recommend the Canadian practice of lining brick flues with aluminium sheet if condensation is unavoidable.

Reference to Table I. shows the quantities of water vapour in the combustion products from various fuels under normal conditions. The relatively high concentration from coal gas in conjunction with the high boiler efficiency and therefore low flue temperature renders this fuel particularly liable to create condensation troubles.

Fig. 7 shows the temperature at which condensation will occur with various amounts of excess air, using gas and oil as fuels. With a normal dilution of products about 140° Fahr. is the critical temperature for the former, while with the latter it is about 30° Fahr. lower.

PREVENTION OF CONDENSATION.

Although the evil effects of condensation can be eliminated, its prevention is clearly to be preferred. The introduction of a

[1] C. H. Lees. Proc. Roy. Soc., 1914-1915A. Vol. 91.
[2] Stanton & Pannel. Collected Researches N.P.L., 1914. Vol. 9.
[3] R. E. Wilson, W. H. M'Adams, and M. Seltzer. Journal of Industrial and Eng. Chem., 14,105 (1922).

*e.g., For rates above 20 lbs. of coal consumed per square foot of grate area per hour $r = 9P_1 - 11{\cdot}5$ roughly.

greater amount of excess air will lower the critical temperature appreciably and this may be accomplished at the baffler of a gas consuming installation without prejudice to the boiler efficiency. It involves, however, a flue equipment of greater capacity and its good effect is partly off-set by the lower flue gas temperature which must result.

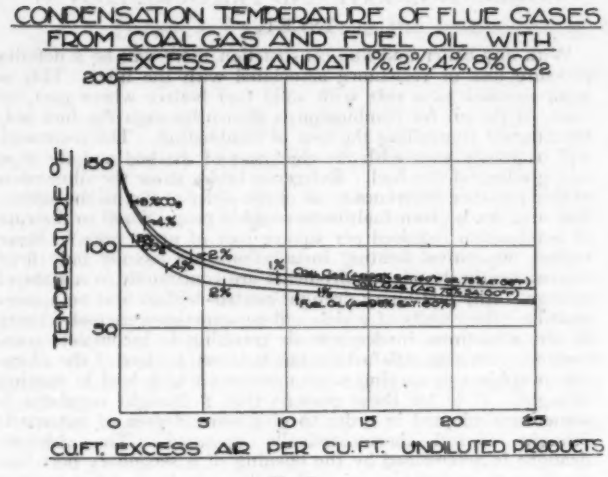


Fig. 7.

Of course a lower thermal efficiency resulting in higher flue gas temperature will have beneficial result on condensation but the sacrifice entailed scarcely recommends this as a normal solution. A reduction of the heat losses from the flue pipe by means of external lagging or by using some insulating material such as asbestos cement will be an advantage, but the advantage may be found somewhat disappointing. Reference has earlier been made to the high temperature gradient which is found even in small flue pipes.

Fig. 8 shows the result of a temperature traverse across the two diameters of 4-in. flue pipe in sheet metal and asbestone, the heat input at the base being similar in the two cases. The mean temperature on the asbestone flue falls off more slowly than on the sheet metal, but in both cases the high temperature gradient has resulted in edge temperatures far below the mean and approaching the critical condensation temperature almost within the first few feet of run. Condensation will clearly

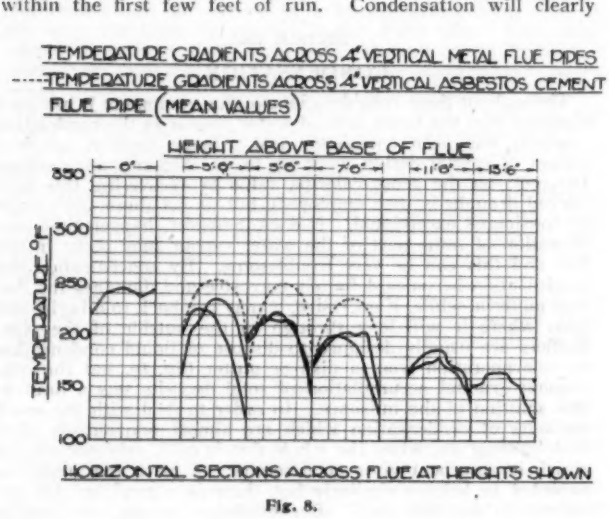


Fig. 8.

occur long before the mean flue gas temperature has reached the critical temperature. If, therefore, condensation is threatened, the risk may be greatly diminished if a long straight run is broken by elbows or bends which cause the hot gas core to mingle with the cooler gas shell and so re-establish the mean temperature across the moving mass.

Tests by temperature traverse immediately before, between, and after two 90° elbows on a vertical run of 4-in. flue give the following interesting results:

—	Mean Edge Temperature.	Highest Temperature of Flue Gases.	Maximum Temperature Difference in Flue Gases.
	° Fahr.	° Fahr.	° Fahr.
Before	172	329	157
Between	239	313	70
After	245	291	46

Heat loss will thereafter take place at a higher rate owing to the higher edge temperatures, but the disturbance of the locally reduced edge temperatures will have beneficial results as regards condensation.

With bends this mixing effect is less marked, depending upon the radius of bend and the disturbance created thereby.

SECTION 11.

EXPERIMENTAL APPARATUS.

It may be of interest to give some brief description of one of the pieces of apparatus used in connection with this work on natural draught. The design now in use is the result of many revisions, and, if not perfect, is at least reasonably accurate in its results and convenient to operate.

Air only is used, heat in known quantity being supplied by triple nichrome wire grids arranged across an enlarged cylindrical portion at the base. The electrical input is, of course, under control. This heating portion is externally lagged with layers of crinkled aluminium foil (Alfol), the heat capacity of this being very small. The heat loss from the black iron outer casing is calculated while the radiation loss downwards is picked up by a 2 ft. diameter double walled calorimeter, through which water is circulated. The heat loss through the walls of the heating cylinder with adapter amount to 5 to 10 p.ct. of the whole radiation losses into the base, the calorimeter picking up about the same amount. The balance of the heat, 80 to 90 p.ct., is taken up by the air which has free entry at the base through the grid and thence to the flue attached to the adapter. Perforated bafflers are arranged just below the adapter to prevent direct radiation up the flue.

Air flow is gauged by temperature measurements at the adapter, a platinum resistance grid, thermo-couples and thermometers being used at different times and for different reasons. Mean temperatures along the flue are gauged on platinum resistance grids, temperature traverse being carried out with copper-constantan couples.

Rough calibration checks were carried out with an anemometer. Closer analytical checks were carried out over the flow range employed by the introduction of a known flow of nitrogen at the base, gas samples being drawn for oxygen analysis. Carbon dioxide was also used. Complete mixing without disturbance of flow was achieved by using a brush of capillary tubes giving a 32 point entry for nitrogen or carbon dioxide distributed over the area of the intake.

The flow measurements taken on the temperature basis were found to be extremely sensitive, the presence of a flat plate at three diameters distance from the exit end of the pipe having measurable effect.

Measurements on the long flue pipe lengths were obtained by mounting the apparatus on the top of a lift in a 40 ft. well, increasing the flue length from a staging at the top as the lift was lowered.

Fig. 9 shows some results obtained on a 4 in. diameter sheet metal flue together with figures obtained

(1) by direct calculation, assuming no flue resistance; and

(2) by similar calculation after first correcting the mean temperature.

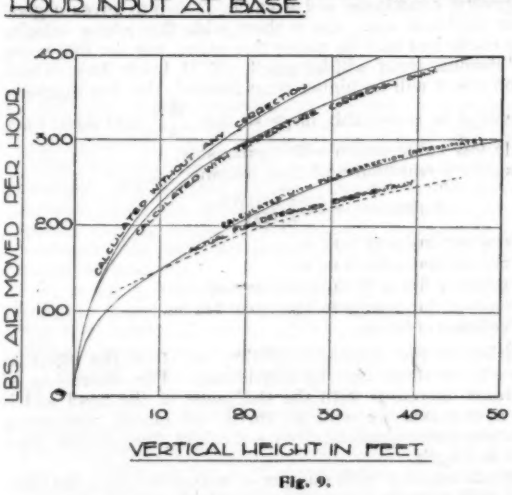


Fig. 9.

A direct calculation of the flow using the complete expressions involving resistance and heat loss is too laborious to be undertaken, but an indirect check was obtained by accepting the figures obtained and substituting back. The values thus found for the resistance were checked against the values ob-

tained by calculation, and reasonably close agreement was obtained. The calculated values showed for agreement a slightly higher value for flow than that obtained on short lengths of flue, while the position was reversed for the taller flues. These discrepancies are easily accounted for by the variable external temperature which could not be controlled, the effect of which is marked (fig. 3).

The curves represent a gross electrical heat input of 9270 B.Th.U. per hour, so that the results in fig. 9 represent a steeply graded part of the flow curve (fig. 3) on which internal and external temperatures have a big influence.

SECTION 12.

CONCLUSIONS.

For any given boiler and fuel the values may be expressed (*cf.* Table II.) in terms of f, where f = boiler rating = B.Th.U. transferred to the water per hour. Hence, simplified expressions of reasonable accuracy may be found for the critical flue dimensions. For a given area or diameter of flue there is a critical height at which the products of combustion will be completely removed and sufficient draught provided to meet combustion requirements under all normal circumstances. Fig. 10 shows this relation for various flues and fuels for a boiler of 1,000,000 B.Th.U. per hour rating.

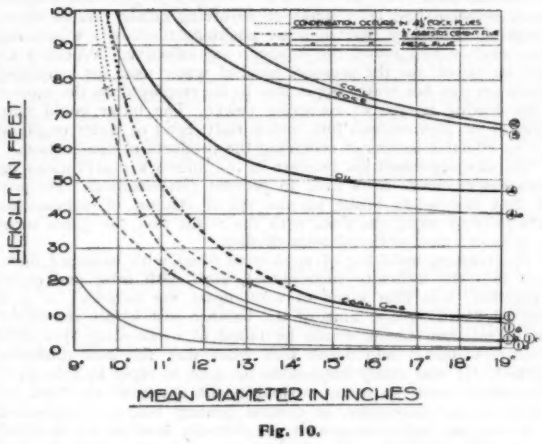


Fig. 10.

COAL GAS.

In order to simplify the general expression it may be assumed that the flue gases at exit contain only a third of their initial heat content. In the example in Fig. 10 the resulting error at 75 ft. is inappreciable, while at 10 ft. a flue 14 in. less high would be adequate.

Resistances at terminal, deflector and bends, if any, are most conveniently embodied with Y as equivalent length of straight flue.

L = Height + equivalent length of fittings + horizontal flue, if any.

Equivalent length of terminal + deflector is taken as

100 diameters = 8d about.

Mean equivalent length of bend is taken as 10 diameters = d about.

The final expression for flue equipment for gas-fired boilers relating to height and diameter will be

$$H = \frac{P_w d^5 + (8d + nd + h)(0{\cdot}81f^2 \times 10^{-9}) + 1{\cdot}34f^2 d \times 10^{-9}}{0{\cdot}022d^5 - 0{\cdot}81f^2 \times 10^{-9}}$$

H = Height of flue in feet.
P_w = Pressure due to wind in lbs. per sq. ft.
d = Diameter of flue pipe in inches.
h = Total length of flue minus total height of flue in feet.
n = Number of bends in flue equipment.

Curve (1) shows the relation between critical height and mean diameter for a normal installation embodying two bends and a 10 ft. length of horizontal. The adequate margin (since draught deflector is used) of 0·1 lb. per sq. ft. is allowed for wind pressure.

Curve (1*a*) shows the relation for a similar flue having no bends or horizontal lengths.

Curve (1*b*) shows the relation as for (1*a*) but without allowance for wind pressure, the effect of which is seen to increase with the greater height of flue (due to extra frictional resistance).

Curve (1*c*) shows the same relation as (1*b*) supposing the flue itself to offer no resistance.

Curve (1*d*) shows the same relation as (1*b*) but assuming baffler and terminal offer no resistance. The effect of these fittings is greater than that due to flue resistance and this fact stresses the importance of choosing these fittings with care.

The critical points above which condensation troubles may arise in the flue are calculated from the heat loss expressions. It is assumed that this may occur if the mean flue gas temperature at exit falls below 190° Fahr. (about 50° Fahr. above actual condensation temperature). For the three common flue construction materials the value of dL should not exceed the following:

Metal flues	$248f \times 10^{-6}$
½ in. asbestos cement	$414f \times 10^{-6}$
4½ in. brick	$737f \times 10^{-6}$

NOTE.—Gas-fired boilers of special construction with which draught deflectors cannot be fitted must, if natural draught is used, have higher allowance made for wind pressure and for boiler resistance (*cf.* Oil).

COAL AND COKE.

Since ample heat is available with these fuels so that the clearance of products is about in the maximum zone (fig. 3) no assumption need be made about the degree of heat loss. The general expression is therefore derived from the simplified expression mentioned. No draught deflector, of course, can be used, and absence of terminal resistance is assumed.

$$H = \frac{(P_w + P_1 + P_2)d^5 + (nd + h)(1{\cdot}69f^2 \times 10^{-9}) + 2{\cdot}77f^2 d \times 10^{-9}}{0{\cdot}038d^5 - 1{\cdot}69f^2 \times 10^{-9}}$$

P_1 = Pressure difference between bottom and top of fuel bed in lbs. per sq. ft.

P_2 = Pressure difference between top of fuel and base of flue in lbs. per sq. ft.

Curve (2) shows the height-diameter relation for coal, which only differs from coke, Curve (3), in that an extra inch is allowed on the diameter for the accommodation of soot deposits.

In both cases, the equipment is assumed to embody two bends and 10 ft. of extra flue in respect of oblique runs.

The pressure drop in fuel bed and boiler flues is very dependent upon rate of combustion, and care in stoking, and 1·5 lbs. per sq. ft. is taken as the lowest reasonable loss to allow. An adequate margin must also be allowed for wind pressure and 1 lb. per sq. ft. appears (fig. 5) to be a reasonable minimum. This last figure must largely depend upon the position of the terminal in relation to adjacent buildings, &c.

The great contrast between the critical heights for solid fuel as compared to gas fuel is due to the allowance necessary for the pressure losses in the boiler and the margin necessary to offset an unfavourable wind.

OIL.

Two curves (4) and (4*a*) are shown for oil, the former derived similarly to that for coal gas by assuming flue gases at exit contain only a third of their initial heat at base of flue. The general expression for oil will then be

$$H = \frac{(P_w + P_2)d^5 + (nd + h)(1{\cdot}16f^2 \times 10^{-9}) + 1{\cdot}90f^2 d \times 10^{-9}}{0{\cdot}033d^5 - 1{\cdot}16f^2 \times 10^{-9}}$$

For curve (4) it is assumed that the pressure drop in the boiler flue ways, &c., is 0·5 lb. per sq. ft., while 1 lb. per sq. ft. margin is allowed to offset unfavourable wind pressure.

Curve (4*a*) is calculated from the shortened expression, but the flue gas temperature is not enough to justify the lower critical dimensions shown which are applicable only to the range of maximum clearance of products (fig. 3).

As with solid fuel greater height is essential with oil as compared to gas as a fuel owing to the absence of a draught deflector necessitating greater pressure drop allowance in respect of wind pressures and of the boiler itself.

Owing to the higher flue temperatures condensation troubles should not normally be experienced.

GENERAL.

The use of special equations for the different fuels may be inconvenient, and the following expressions derived from the above will give adequate margin for any normal fuel where extreme accuracy is unnecessary. Owing to the various flue gas temperatures of the several fuels, the height necessary to compensate for wind pressure and for pressure loss in fuel bed and boiler flues cannot easily be combined into one general expression, and a separate allowance must be made on this account.

If $H = H_1 + H_2$

$$H_1 = \frac{4(nd + h^*) + 7d}{9d^5 f^{-2} \times 10^7 - 4}$$

*NOTE.—Add here also equivalent lengths for terminal and draught deflector, if necessary. (See Coal Gas.)

The height H_3 represents the allowance to be made for the pressure loss above mentioned.

Approximate Value of H_3 per 0·1 lb. per Sq. Ft. (0·02 w.g. about) Pressure Loss due to Wind, Fuel Bed, and Boiler Flues.

Fuel.	If $\frac{H_1}{d} < 1$	If $\frac{H_1}{d} > 1$ < 2	If $\frac{H_1}{d} > 2{\cdot}0$ $< 2{\cdot}5$
Coal gas	5½ ft.	6½ ft.	7½ ft.
Coal and coke . . .	3¼ ,,	3¾ ,,	4 ,,
Oil	3¾ ,,	4 ,,	4½ ,,

The height so derived in common with the special final equations makes no allowance for soot deposits, and where these are anticipated a suitable increase must be allowed over the diameter used in the calculations.

Discussion.

Mr. J. G. CLARK remarked that past methods of ascertaining correct fluepipe equipment had been based on empirical notions; and there was no doubt that, with more scientific information, they would be nearer a solution to the problem. Combustion was a very important matter in both domestic and industrial work; and the more light which was thrown on the subject, the better. One of the most striking things to those who had not studied the question was the magnitude of wind pressure in relation to the natural forces set up by combustion. A certain amount of heat in the appliances was employed for creating an up-current, promoting combustion, and conveying the products of combustion to the outer air. The wind forces, however, far exceeded the force set up by the heat; and to his mind this was one of the most important features of Mr. Masterman's paper. The author had not alluded to one aspect of ventilation as far as certain appliances were concerned. If they allowed the wind pressure to operate on the inlet as well as on the outlet of an appliance, then the latter would continue to function as though it was operating in still air. He had thought about this a great deal, and realized how difficult it was to ensure complete balance of pressure between inlet and outlet. If they could design equipment so that the difference in balance created an up-draught, they would avoid many difficulties. The speaker then went on to discuss flue terminals. He said he had seen many which, though masterpieces from the point of view of appearance, were totally ineffective from the main aspect of ventilation. Another important section of the paper, observed Mr. Clark, was that relating to condensation of water from the products of combustion—an effect determined by the temperature of the gases passing up the flue. Some years ago he had made calculations showing that the amount of heat available in the flue gases was enough to carry away the water as vapour; and Mr. Masterman had thrown light on this question. There were, of course, ways and means of minimizing the effects of corrosion. There was the use of aluminium and ferrous substances which were relatively incorrodible, and asbestos cement. He could not help thinking how complex the subject of ventilation was compared with the laws of electric circuits. It was child's play to calculate the quantity of current flowing through an electric circuit, but it was certainly no child's play to calculate the flow of combustion products from solid, liquid, and gaseous fuels; and he hoped that, by further study, they would eventually be able to reduce gaseous flow to the simplicity of the electrical circuit.

Mr. CATHCART, referring to Mr. Masterman's observations on the loss of pressure due to the thickness of the fuel bed, asked the author whether he could advance figures relating to the losses due to varying depths of fuel bed. Was there a maximum allowable thickness?

"PULL" OR "PUSH."

Mr. COPPING suggested that the expression "chimney pull" was inaccurate; it ought to be "chimney push," for the chimney did not "pull" the products of combustion up the flue—it was the cold inlet air which acted as the driving force. He expressed surprise that the calorific value of a bituminous coal was taken as 15,000 B.Th.U. per lb. gross and 14,500 B.Th.U. net. Also, when speaking of transmission loss, did the author imply the loss per square foot of external surface of the pipe or of internal surface?

Mr. MASTERMAN: External surface.

NEED FOR ADEQUATE VENTILATION OF GAS APPLIANCES.

Mr. STEPHEN LACEY said he would like to take the opportunity of congratulating Mr. Masterman on a paper which reflected very great credit on the research laboratories of the Gas Light and Coke Company. In his foreword, the author stated that the performance of a heating installation might easily be prejudiced by the use of incorrect flue equipment. This, of course, was true of all types of heating appliance, but it was particularly true where gas was the fuel. When solid fuel was employed, the presence of smoke in a room compelled rectification of the flue equipment; but with gas the products of combustion were invisible and almost odourless, and appliances were often credited with bad results arising from ineffective flues. Everything should be done to ensure adequate ventilation of gas appliances. There existed much ignorance of the design of flue equipment on the part of those who installed appliances. In this respect the speculative builder was the chief offender, though architects were not always beyond criticism. He had seen builders attempt to ventilate gas appliances by means of horizontal pipes passing through an external wall, or by pipes ending in badly designed flueblocks placed under the eaves of the roof. And one of the main reasons for bringing this subject before the Institution of Heating and Ventilating Engineers was that the members were experts in ventilation, and were in a position to influence builders and architects.

INDUCED DOWNDRAUGHT.

Mr. ADAMS, remarking on the virtues of the baffler, said that its use not only prevented bad combustion, but diluted the products of combustion with air from outside in the event of downdraught. There was another phase of downdraught which he would like to mention—induced downdraught. If, for example, there were two fireplaces in one room, it did not always follow that there was sufficient inlet air for both grates. The chimney with the stronger pull would then actually draw air from the chimney with the weaker pull; and one could imagine what would happen if the stronger flue was connected to a coal fire, and the weaker to a gas fire.

Mr. T. F. C. POTTERTON expressed his preference for a straight baffle as distinct from the bent-tee type. He had not found the latter very effective as a baffler.

Mr. ORD asked the author if, in his calculations, he had taken into account the shape of the flue.

Mr. THOMAS said that, in regard to fluepipes of gas-heated appliances, no mention had been made of revolving cowls. With these, there was the difficulty that in some positions the cowls would not revolve; and he had found the lobster cowl effective. Would it be possible, he asked, for the pressure head of water used for supplying instantaneous gas hot water apparatus to be employed as the motive force for driving a type of revolving cowl? The latter could take the form of an archimedean fan, and a 10-ft. head of water ought to provide an effective means of removing the products of combustion.

Mr. BROOKS expressed his interest in the author's observations on the insertion of bends in a flue, to prevent condensation. He presumed that the bends broke up the spiral column of combustion products passing along the flue, with the result that the gases occupied a greater cross-sectional area of flue.

Mr. MASTERMAN, speaking of appliances fitted with balanced flues, observed that the difficulty encountered, even with inlet and outlet close together, was that gusts of wind upset the balance; a gust of wind might strike one limb of the balance just before the other. It was hoped that means would be found of overcoming this difficulty. Mr. Cathcart had asked him what was the best thickness of fuel bed. It was really impossible for him to reply to this question, for there were so many variables—the shape of the fuel, its size, and so on. Moreover, in central heating boilers, it was not usual to feed the fuel continuously, so that the level of the fuel bed was constantly shifting. The figures of resistance which he had given in his paper were only approximate. He agreed with Mr. Copping that a more scientific definition of the action of a flue was "chimney push" rather than "chimney pull." As far as the calorific value of bituminous coal was concerned, he was under the impression that he had taken a fair and typical example; in any case, it did not make much difference to the final figures. He was grateful to Mr. Adams for calling attention to induced downdraught caused by multiple flues. Mr. Potterton had raised the question of baffles for use with solid fuel fires. With fuels other than gas, the products of combustion contained smoke, sulphur dioxide, and at times a certain amount of carbon monoxide; and if a baffler were fitted which allowed downdraught to disperse the combustion products in the room in which the appliance was fitted, the conditions would, of course, be unbearable. The bent-tee baffler, or some other design of the same type, appeared to be the only method of dealing with downdraught in flues connected with solid fuel fires; and his own tests on a bent-tee baffler had shown that it was effective and satisfactory in winds up to 60 miles an hour. In reply to Mr. Ord, he had mentioned the shape of the flue in the paper. He had taken a square flue for calculating heat loss and friction, and, from the point of view of cross-sectional area, he had taken a round flue. The calculations applied to either square or circular flues. With flues of strange shape, conditions would be worse. The idea of harnessing the head of water to drive a combustion products fan in connection with a geyser, put forward by Mr. Thomas, was most interesting. In regard to the remarks of Mr. Brooks, he was not at all sure that the flow along a flue could be termed "spiral." Personally he suggested that a vortex flow was a better definition. He intended to study this question by an optical method. Certainly, with turbulent flow there was an inner hot cone of gases and an outer cooler cone, and these two phases persisted.

A vote of thanks to the author and to the Gas Light and Coke Company, proposed by the CHAIRMAN (Mr. J. L. Musgrove) concluded the meeting.

Need for Gas in Hospitals.—An electric light failure occurred at Hounslow last week. When the light went out at the Hounslow Hospital acetylene lamps from the ambulance were rushed to the maternity ward, and in this improvised light a baby was born. In the casualty ward an accident case was being treated, and the doctors had to stop their work. The West Middlesex Hospital, Isleworth, was also affected.

The Mechanical World Year Book.—Messrs. Emmott & Co., Ltd., of King Street, Manchester, have just published the 1930 Edition of the Mechanical World Year Book, at the net price of 1s. 6d. This useful handbook, besides containing the calendar and diary for the year, has considerable practical information in the shape of temperature conversion tables, comparative stresses, price equivalents, Post Office Regulations, &c.

Corrosion—A Problem in Protective Coatings.

By F. N. SPELLER, of the National Tube Company, Pittsburgh.

[Paper before the Montreal Chapter of the American Society for Steel Treating.[1]]

The large and increasing tonnage of metals subject to corrosion in the industries has brought the question of conservation to the front as a major engineering problem. In pipe lines, tanks, and oil refineries, for example, a recent census shows that losses and cost of maintenance amount to more than one hundred million dollars a year in the oil industry alone. In modern cracking stills ordinary steel tubes often last only three or four months. Prevention of corrosion may be worked out along three lines: By developing more resistant metals, by reducing the corrosive character of the environment, or by the use of more stable protective layers of material which are cheaper and much more resistant than the metal.

Twenty years ago the prevailing opinion was that the rate of corrosion of metals, like their common physical properties, depended mainly on certain inherent characteristics. While it is probably true that in some cases the solution pressure or tendency to corrode is very different in different metals—such as platinum and iron to take extreme examples—this does not explain fully the difference in rate of corrosion of different kinds of iron, aluminium, brass, and other of the more common and less durable metals. For the immediate discussion let us confine our attention to the various well-known ferrous alloys. As a result of experience it is now generally conceded that the *rates* of attack of wrought-iron, cast-iron, and the various forms of ordinary steel in soil and water are, as a rule, but little different; in the atmosphere more variation is found.

Relative Corrosion of Wrought-Iron, Steel, and Pure Iron.

It is surprising how much has been taken for granted without any real evidence on the question of the relative merits of wrought-iron, steel, and pure iron. A little frank discussion of the facts of the case may not be out of place at this time.

Large investments are now being made in low-cost methods of making so-called wrought-iron by mixing molten cinder with hot steel particles without the use of the labour formerly required in the old hand-puddling process. Before using synthetic wrought-iron on a large scale, it would seem advisable to determine whether the old iron was materially better than modern steel, as some claim it to be, and also whether the new iron made by radically different methods is as good as the old. The evidence from comparative tests is certainly not convincing as to the alleged superiority of the older material. However, widespread advertising has founded and maintained industries where the public are unable to check the claims readily. For example, a large eastern gas company used wrought-iron from 1898 to 1906, and steel pipe from 1906 to 1916. They published the number of services which failed each year during this period with respect to the time in service.[2] These data were charted and published by a manufacturer of wrought-iron pipe on the basis of failures of both materials, for each year of service per 10,000 services installed.

The method of presenting these data leads to the conclusion that after several years the steel corrodes four or five times as rapidly as the iron. This method of comparison ignores the fact that the pipes were laid at different periods and in different localities. It is well known that soil conditions vary considerably in large cities, but the fact that this company is still using steel pipe exclusively indicates the erroneous nature of this comparison. Their real conclusion from this experience and tests is " that there was very little difference in the corrosive effect of soils on wrought-iron and steel pipe "—very different from the one expressed in the report of these tests as issued by the wrought-iron interests.

Another analysis of these data, accepted by the gas company and based on the probable average life of services for each year of installation where sufficient data are available, was obtained by estimating by probability curve calculations the average life of the services installed in each year from 1898 to 1914[3] from the failures recorded for each year. The failures to date of steel pipe installed after 1914 are too few to give an accurate estimate. The wrought-iron pipe installed prior to 1903 shows a somewhat longer life than steel; after this date there is very little difference. This has been explained by the fact that previous to 1903 most of the services were laid in virgin soil, whereas after that time as the city limits were extended most of the services were placed in filled ground.

It is significant to note that the United States Bureau of Standards soil tests indicate no material difference between wrought-iron, copper, steel, and other kinds of commercial steel pipe in many typical soils, in various parts of this country. The variable factors in soil corrosion are more numerous and harder to control than in water or air, so that the agreement of the general averages of these two sets of data, one from actual experience and the other from measured corrosion in a wide variety of soils, is significant. Most of the large gas and oil companies, which use thousands of miles of pipe line, have come to the conclusion that there is practically no difference between these materials.

Corrosion and Electrochemical Theory.

Early investigations by the writer indicated that ordinary segregation of foreign materials in steel had no influence in controlling the location of the areas attacked (anodic areas), but that the external potential, such as that induced by relatively large areas of mill scale, was sufficient to direct and maintain the attack on certain anodic areas and cause in time perforation of the metal.

Before considering certain preventive measures, it may be well to state briefly the principle of the electrochemical theory of corrosion which is now generally accepted in explanation of the initial corrosive attack at normal temperature. At high temperatures and occasionally at temperatures not far above normal, direct chemical attack may occur. The initial reactions when metal is first exposed to water and oxygen are:

$$\text{I.} \quad \text{M (metal)} + 2\text{H}^{+} \text{ (ionic)} = \text{M}^{++} \text{ (ionic)} + 2\text{H (atomic)}$$

$$\text{II.} \ (a) \ 2\text{H (atomic)} + \tfrac{1}{2}\text{O}_2 = \text{H}_2\text{O}$$

$$(b) \ 2\text{H (atomic)} = \text{H}_2 \text{ (molecular)}$$

As a result of these reactions the solution tends to become alkaline at cathodic areas and acid at the anodes. Most metals when first exposed to water show initially a high rate of solution, which quickly slows down as the polarizing film of hydrogen forms on cathodic areas, and the reaction can only continue by removal of the atomic hydrogen film either by combination with free oxygen or as hydrogen gas.

In case corrosion products are insoluble, surface films form which greatly retard and sometimes stop the reaction. The metal surface may thus become completely covered with a film of corrosion products ranging in thickness from an atomic layer to one of measurable dimensions. These films may form on anodic or cathodic areas. After a film forms over an anodic area, the potential may be reversed, and this change of potential may occur repeatedly, resulting in fairly uniform corrosion.

Ordinary corrosion is dependent upon the maintenance of a supply of free oxygen and water at the metal surface and is influenced largely by temperature, rate of motion, hydrogen-ion concentration, local changes in potential due to oxygen concentration cells or dissimilar metals in contact, protective films, and many other variables. The retardation of corrosion is most generally brought about, however, by the formation of more or less impermeable protective films on anodic areas. These films start to form shortly after the metal comes into contact with a corroding solution. They consist essentially of the products of corrosion and attain their maximum protective power after a certain period of time. This may be looked upon as a self-healing property possessed by some metals without which they would have a considerably higher rate of deterioration and be much less useful. It should be our aim to cultivate this valuable property in metals. In fact, it seems to the writer that metals having high corrosion resistance may be better developed by a scientific study of the stability and formation of surface films than by the old cut-and-try method of making and testing the effects of various alloying elements. Some work has already been done on the study of the electrical resistance of these films, but more knowledge of the initial rate of attack and the rate at which corrosion is retarded by the alloying of certain elements with iron should be helpful in explaining the mechanism of the resistance to corrosion.

When clean iron, aluminium, zincs, and many other metals are exposed in a corroding medium (either in a solution or a gas at ordinary or higher temperatures), the rate of attack is usually rapid at first and slows down quickly in a short time to a lesser rate, which may be comparatively uniform unless there is some change in the corroding medium. The rate of attack is retarded at a rate depending upon the capacity of the metal to form a self-protecting film, which is very rapid in the case of such metals as high-chrome iron and aluminium, and much slower with other metals, depending in all cases very much on the corroding reagents and the nature of the products of corrosion. This is a very significant observation, which requires much more experimental work before it can be

[1] Delivered Jan. 14, 1929.

[2] Proc. Am. Gas Assocn., **6**, 1234 (1924); supplemented by data in later reports of American Gas Association Distribution Committee.

[3] Kendall, Am. Gas Assocn. Monthly, **10**, 493 (1928).

stated as a law in more precise terms; but it can be confidently said at present, based on a large amount of experimental evidence, that external influences predominate in controlling the corrosion rate of any metal. This being true, it is important to understand the various ways in which the rate of attack is governed by changes in external conditions, including the surface films that naturally form on a metal surface and tend to re-form when broken by a self-healing process.

Natural Protective Films.

For lack of space the subject of de-aeration and other means by which corroding media may be rendered much less active will be passed over here, except that it should be noted that such means are sometimes more economical than other preventive measures.

A few examples of protection of metals by building up natural protective films will now be considered.

A natural protective skin is often formed under atmospheric condition at normal temperature. In 1909, the writer reported a study of old French iron and steel on the Panama Canal site.[4] Some of this old material was thoroughly protected by an adherent oxide, but showed no evidence of painting. However, when the surface skin was machined off, and the clean metal was exposed with modern steel similarly prepared, they both corroded rapidly at about the same rate. Evidently the initial cycle of weather conditions (wetting and hot-drying) has much to do with the ultimate life of the metal, depending upon whether or not a stable protective film is formed.

Evans[5] reports an investigation which he made on some old galvanized-iron roofing sheets which had resisted exposure to sea spray in the Scilly Islands successfully for fifteen years. He showed definitely that the older material was more resistant than new galvanized sheets, and that this was due, not to any essential superiority in the older zinc coating, but to a permanent protective film that had evidently been acquired during the initial period of exposure. There is considerable evidence like this pointing to the fact that the conditions prevailing when the metal is first exposed, such as the physical character and adherence of the early products of corrosion, have considerable influence on the subsequent life of the metal.

Evans[5] artificially produced a protective film on a zinc-coated steel surface by alternately spraying with 0·01 *N* sulphuric acid or 0·5 *N* sodium chloride and drying, which increased the resistance of the metal when later immersed in 0·5 *N* sodium chloride.

Certain inhibitors reduce the rate of solution of metals in acid solutions. It has been shown that this is due to an increase in the hydrogen over-voltage which is generally assumed to be due to formation of a film of discharged inhibitor substances adsorbed on the cathodic areas. The theory of inhibitor action has been well stated by one group of investigators as follows:[6]

> When immersed in acid, iron goes into solution at the anode areas, forming ions and discharging hydrogen ions at the cathode areas. These cathode areas may be said to occur principally in the narrow spaces of the grain boundaries in steel or between the metal and slag in wrought-iron. Most inhibitors are either bases, such as quinoline, or positively-charged colloids, and when these are present they travel to the cathode areas with the hydrogen. When the positively-charged heavy particles are discharged, they cannot escape by gaseous evolution, and accordingly are adsorbed on the surface, building up a protective layer.

Another well-known example of film protection is found in the action of alkalis in solution. Some work done a few years ago by the writer and one of his associates[7] indicated that the initial rate of corrosion of iron in water having various concentrations of caustic soda did not vary materially, but that several minutes later the corrosion rate had decreased to a fixed minimum depending upon the hydroxyl concentration. This is explained by the lower solubility of ferrous hydroxide in the more alkaline solutions.

The relationship between the equilibrium values for alkalinity expressed as calcium carbonate and the pH value in distilled water and in Baltimore tap water has been plotted from experimental data obtained by Baylis.[8] For any definite alkalinity a calcium carbonate scale tends to form when the pH value is raised above the equilibrium value for any particular water. This method of controlling corrosion and preventing "red water" has been successfully put into practice in the city of Baltimore.

Sodium silicate has been found useful in some waters to assist in building up protective layers consisting of the products of corrosion, silicates and carbonates from the water; as little as 10 p. p. m. is sufficient in some cases to prevent "red water."[9] This treatment has often been found useful in waters from which scale-forming constituents have been displaced by the zeolite process. The solution of lead may be stopped by the use of a small amount of soluble silicate in the same way. Silicate layers build up slowly and break down after a certain period of time, when the water treatment is discontinued.

May and Carpenter[10] give some interesting examples of the building up and repair of broken surface films on non-ferrous condenser tubes, and trace the formation of these films by a series of measuresments of the film potential.

Passivity is induced in iron and ferrous alloys, zinc, aluminium, copper, and other metals when they are subjected to the action of strong oxidizing reagents such as strong nitric acid, chromic acid, or a rather strong solution of chromates.[11] A metal may also be rendered passive to corroding reagents by anodic attack. To form such a film the voltage must be sufficiently high to cause evolution of oxygen at the anode.

So long as a certain low concentration of the passivifying reagent is in contact with metal, it is kept immune from attack under the action of corrosive solutions, even with alternating stresses that in the absence of the inhibitor would cause rapid destruction of the metal. McAdam[12] has shown that the endurance limit of iron and some other corrodible metals is greatly reduced by the combined action of cyclic stresses and corrosion produced by a stream of water impinging on the stressed specimen. The present writer and his co-workers have shown that 200 p. p. m. of sodium chromate in ordinary tap water will completely overcome this effect, evidently by maintaining the passive film.[13] In reporting their experiments on cyclic stress and corrosion, particular attention was called to the fact that a narrow band of lacquer or loose rubber surrounding the test piece caused failure, evidently due to a localized acceleration of corrosion, which was sufficient to overcome the passivifying effect of the inhibitor, which otherwise gave good protection under the same stress.

All these observations and experiments indicate that passivity is due to invisible film protection. Evans[14] showed that some of these invisible passive films may be raised off the metal surface and rendered visible.

It is not surprising that these very resistant films are so thin as to be invisible, as corrosion under these conditions is quickly arrested and the growth of the film must then cease. Evans[14] has shown that oxygen uniformly distributed over the surface of a metal in water tends to passivify iron. This may explain the abnormal resistance occasionally found in old iron and steel, and zinc-coated iron and steel. On the other hand, the present writer has found that variations in oxygen concentration have a marked tendency to break down protective films. There is, therefore, good ground for considering passivity of all kinds, including the slow corrosion of special steels resistant to corrosion, as due to film protection.

The accelerating influence of contact between dissimilar metals may be offset more or less by the use of passivifying reagents. To passivify metals, in practice, it is most economical to use sodium dichromate with sufficient caustic soda to form the normal chromate. The writer has applied this treatment to stop corrosion in water cooling systems where the water is recirculated over and over. About 200 p. p. m. of the dichromate are usually sufficient, though the amount required varies with the composition of the water, particularly its chloride content. This treatment is also useful in retarding the action of refrigerating brines on plain and galvanized steel. A 20 p.ct. brine requires 1500 p. p. m. of dichromate and 400 p. p. m. sodium hydroxide. Naturally the surface film is harder to maintain in high-chloride solutions, but practical experience for more than a year at several ice plants has demonstrated the value of this treatment by which the corrosion of equipment is reduced to 80 p.ct.[15]

Protection with Thick Coatings.

Thick coatings of more or less inert material are often applied economically to protect the more expensive steel construction such as underground pipe. As a rule, paints are hardly worth the expense of application, except where exposure is to the atmosphere.

In this class of protection we have Portland cement, concrete, and re-inforced bituminous coatings. Cement-lined pipe and fittings are now available for water service at ordinary temperature in all the common sizes. The coating is applied by centrifugal action for the larger sizes and by drawing a mandrel through the pipe for the smaller sizes. Neat cement

[4] Speller, Proc. Am. Soc. Testing Materials, **9**, 440 (1909).

[5] Evans, "Corrosion at Discontinuities in Metallic Protective Coatings," presented at Institute of Metals, Liverpool, England, September, 1928.

[6] Chappell, Roetheli, and McCarthy, Ind. Eng. Chem., **20**, 596 (1928).

[7] Speller and Texter, Ind. Eng. Chem., **16**, 393 (1924).

[8] Baylis, Am. Water Works Assocn., **15**, 598 (1926).

[9] Speller, "Corrosion—Causes and Prevention," p. 350, McGraw-Hill Book Co., 1926.

[10] May and Carpenter, "The Corrosion of Condenser Tubes," presented at Institute of Metals, Liverpool, England, September, 1928.

[11] E. L. Chappell has shown that hot-dipped zinc-coated pipe, when quenched in water carrying a small amount of chromate, is much more resistant to corrosion than when the chromate is not added.

[12] McAdam, Proc. Am. Soc. Testing Materials (preprint) **41**, 29 pp., June, 1928.

[13] Speller, McCorkle, Mumma, *Ibid.*, Reprint No. **42**, 9 pp., June, 1928.

[14] Evans, J. Chem. Soc., **1927**, 1020.

[15] Refrigerating Eng., **12**, 22 (July, 1928).

with 25 p.ct. fine sharp sand is usually employed. For a few months the water passing through cement-lined pipe will be slightly harder and more alkaline, but as the free lime becomes leached out this effect disappears. In New England fifty or sixty years of service have been obtained from cement-lined water pipe.

A new process (Talbot) of centrifugally lining water mains with an asphalt mastic (70 p.ct. sand and 30 p.ct. asphalt) has been developed in England, and plant for lining up to 30-in. pipe has been erected by the National Tube Company in the United States. This gives a very durable coating, but is somewhat more expensive than cement. Enamel and rubber-lined pipes are also available for special purposes.

The protection of pipe lines from soil corrosion is being studied in detail by representatives of the American Petroleum Institute and the American Gas Association. Thick bituminous coatings are generally used, frequently re-inforced with saturated fabric to hold the bitumen on the metal. The Petroleum Institute's Corrosion Committee has recently issued a tentative code of good practice for the coating of pipe.[16]

More Resistant Metals.

Having considered a few examples of unstable metals which may be made less corrodible by the formation of a protective layer on the metal surface without any change in the metal itself or by application of protective coating, let us now consider what can be done towards prolonging the life of the metal by alloying it with other metals.

When the electrolytic theory was first discussed, some were led to the conclusion that a high degree of purity and a more homogeneous structure would give longer life to ordinary steel. Greater purity of the metal has not proved to be the answer except under acid attack. We now know that external factors usually control the rate of corrosion, and that all commercial grades of iron are much alike in being naturally more corrodible under some conditions than chromium, nickel, or copper. Fortunately, iron can alloy with most of these more resistant metals, forming solid solutions that are in many cases much more resistant than the alloying metals themselves. The essential characteristics of a rust-resisting metal are apparently that it would have a low solution pressure and form impermeable, tenacious, and stable surface films in combination with corroding media. These films should be, and usually are, much more stable than the metals which enter into their structure, but as they are attacked differently under different conditions, it is not to be expected that a metal will soon be found that is equally resistant under all conditions. Gold and platinum are at present the only metals that are resistant to nearly all corroding reagents.

Let us take the case of steel with the addition of 0·25 p.ct. of copper, which is now well established commercially. Long-time exposure tests in service have shown an increased life of from two to four times in atmosphere by the addition of this amount of copper to ordinary Bessemer steel, whereas the same steel under water or in corrosive soil is apparently no better than ordinary steel without copper. In the former case, when the metal first goes into solution, copper is precipitated *in situ* and a double oxide of copper and iron is formed. In water, on the other hand, the rust is loosely formed and less dense, suggesting that the small amount of copper is carried away from the corroding surface when the metal dissolves, and therefore plays no part in the formation of a protective layer. It is a curious fact that copper forms a denser film on the more impure forms of steel, so that copper-bearing Bessemer steel is more resistant in certain atmospheres than open-hearth steel or commercially pure iron with the same copper content.

For most purposes where large tonnages of metals are involved, the world is interested in the use of iron as a base for a more durable metal having useful physical properties. Small additions (1 or 2 p.ct.) of chromium, nickel, or silicon to iron have not given encouraging results, under ordinary corrosion, but when the amount of chromium or silicon exceeds 12 or 14 p.ct. a very marked stability is produced, particularly under atmospheric exposure or where the metal is exposed to strong oxidizing conditions. This amount of chromium in solid solution in iron forms a very resistant oxide film which is self-healing except under those conditions where the film is destroyed, as in the presence of an excess of chlorides. High-chromium iron when immersed in copper chloride solution after careful cleaning in the absence of oxygen goes into solution and precipitates copper like ordinary iron. The addition of 8 p.ct. or more of nickel still further increases the stability of the surface film under a wider range of conditions. An attractive field of research is open in the study of the stability of films made up of combinations of oxides. More fundamental information is also desirable on the initial rate of corrosion of these alloys, which appears to depend upon the type of anodic film protection produced in the corroding medium.

These are fundamental problems worthy of the close attention of physical chemists. The nature of the bond which holds these passive films on the metal is also an interesting field of speculation. It may be, as Guertler[17] points out, that the unsatisfied attractive bonds of the surface atoms of the metal bind oxygen atoms to the metal and thus form a primary protective layer (an atomic priming coat as it were) to which a more protective oxide layer is often attached.

High-chromium steel (stainless steel) has been shown by Friend[18] to resist the action of sea water very much better than ordinary steel similarly exposed, except where the samples were partially protected in a wooden rack. All the metals so protected were deeply corroded at that place, probably owing to the difference in oxygen concentration. Small particles of scale on the surface of chrome iron also induce a difference of potential which results in pitting, so that to get the best results the metal should be polished. High-chromium steel is also subject to pitting in corrosive soils. This and other circumstantial evidence, as pointed out before in this paper, leads to the conclusion that the superior resistance of such steels is due to the surface film formed rather than to any great reduction in the solution pressure of the metal by the chromium addition. As the life of the steel is so materially influenced by small variations in surface potential, the surface film hypothesis seems highly probable.

All this being true, it follows that to improve the durability of iron, the compounds of iron and other metals that are most resistant under certain conditions of service should first be investigated, and then the most likely ones selected in an endeavour to form solid solutions of iron and other metals that will form these resistant films when the metal corrodes. The chief alloying metals available in practice are copper, nickel, chromium, silicon, and aluminium. Since double compounds of these metals are as a rule more stable, a research of this kind is likely to take some time and patience. However, much has already been learned by experience, and useful alloys of iron, chromium, and nickel are now available for various purposes where first cost is of secondary importance. A low-priced alloy is needed which will be two or three times as durable as ordinary iron in air, soil, or natural waters without much additional cost. Experience with the iron-chromium, iron-nickel, and iron-silicon series points to the necessity of a large amount (over 13 p.ct.) of these alloying metals in solid solution and does not offer much promise of the early development of a low-cost rust-resisting iron alloy.

Aluminium is an example of a metal that quickly forms a stable oxide film, and on this account possesses high resistance to atmospheric corrosion. In contact with chloride solutions, this film is soon penetrated and destroyed, and, in consequence, under these conditions the metal has a comparatively short life. Aluminium in considerable amounts (perhaps with other metals) may prove to be a useful alloying agent in iron for certain kinds of exposure.

Variations in water, local differences in surface potential, and other factors may affect the stability of the film formed on metals, so that tests should be made under service conditions or by using the same controlling factors that are found in practice. Too often the impatient investigator resorts to an acid test and misleading statements are prematurely published which tend to discredit other work. Popular advertising of special alloys of iron with a dash of this or that and a cryptic name should be viewed with suspicion until satisfactory tests under specific conditions of service are obtained. Thus far no low-priced iron alloy has been put on the market that seems worth the difference in cost except for atmospheric exposure, and ordinary Bessemer steel with a little copper seems to be at least as durable as any other for that type of service.

Conclusions.

1. Corrosion is determined and controlled by influences external to the metal which either form or destroy surface films on the metal.

2. Protective films form more readily in air than in water or soil.

3. Where the metal is continuously in contact with soil or water, commercial steel or wrought-iron suffers about the same under the same conditions of exposure irrespective of method of manufacture or the amount of foreign material present, within wide limits.

4. When exposed in air, however, copper in amounts over 0·15 p.ct. has a marked effect in forming a stable surface coating of oxides which increases the life of the metal at least two or three times. This is the result of tests in service extending over a period of more than ten years. There is no such evidence as yet that other additions give additional life.

5. For highly corrosive conditions where the first cost of metal is not of prime importance, suitable metals are now available, such as the 18 p.ct. chromium-8 p.ct. nickel alloy, but in selecting the most economical alloy for any particular purpose it is important first to study the environment, and select a metal that contains the elements that will be most likely to form a stable surface film under conditions of service.

[16] Proc. Am. Petroleum Inst., December, 1928.

[17] Guertler, Trans. Am. Soc. Steel Treating, **13**, 759 (1928).

[18] Friend, Carnegie Scholarship Mem., **16**, 131 (1927).

Gas-Works' Refractories.

By J. A. SUGDEN, Ph.D., Department of Coal Gas and Fuel Industries of the University of Leeds.

[Yorkshire Junior Gas Association, Jan. 18.]

In order to increase the output of the plant and to obtain the maximum number of therms in the form of gas, the trend of modern gas-works practice has been towards higher and higher temperatures of carbonization. Consequently, the demands made upon the refractory steadily increased, until the time came when it was realized that further advance depended largely upon the improvement of the refractory.

One such development was the introduction of silica. This material was put into use before sufficient examination of its properties had been made, and before the special care which it needs in use had been sufficiently emphasized. The result was that, at first, grave misgivings were felt for its usefulness. However, before we proceed to discuss such matters in detail let us consider the general requirements which must be fulfilled by a refractory material.

Refractoriness Under Load.—The first and obvious essential of a refractory material is the ability to retain its shape and strength at high temperatures. Not only must the material possess a high softening point as determined by the collapse of a small pyramidal test piece, but it must also retain its strength or rigidity at high temperatures when under the load it will have to bear in use.

Constancy of Volume.—Perhaps the most important stage in the manufacture of a refractory is the burning in the kiln. During this process the more fusible particles melt or flux to form a glassy material which serves to bind together the less fusible particles, and thus give the product mechanical strength. While this so-called vitrification is taking place the particles of the material are being drawn together as are particles of sand when wetted with water. Consequently, the material tends to shrink. This is what happens with fireclay, and the higher the temperature of burning, the greater is the amount of shrinkage. Therefore, the material must be fired during manufacture to at least as high a temperature as that to which it will be subjected during use; otherwise the continued shrinkage will cause distortion, or even collapse of the structure.

As will be explained later, silica materials do not shrink, but, owing to other changes taking place, actually increase in size, or "grow," during the burning process. It is, of course, in this case essential that the "growth" should be completed as far as possible in the kiln. These permanent volume changes which are described as the "after-contraction" and "after-expansion" are reduced to a minimum in the present-day well-burnt products, but testing is essential for safety in this matter.

THERMAL CONDUCTIVITY.

The property of thermal conductivity is apt to be overlooked, though it is an important factor in the efficient working of a setting. Actually, the refractory is called upon to act in two opposite rôles according to its position in the setting—one as a conductor of heat and the other as an insulator. The retort wall itself must have an adequate conductivity in order that the carbonizing time shall be short and the through-put of the plant, therefore, high. In the case of intermittent working, it is not actually the conductivity which is the factor involved, but, rather, the "diffusivity," for it is this property which determines the rate at which a body may be heated up. It is related to the conductivity (K) in the following way:

$$\text{Diffusivity} = \frac{K}{C.S}$$

where S = apparent specific gravity and C = specific heat of the material. It is a measure of the rate at which a heat wave is transmitted through the material. It must be pointed out that the limiting factor in the heat transmission is the comparatively low conductivity of the coal charge. The flue walls of the recuperator must also have a high conductivity in order to facilitate the heat exchange.

The rest of the refractory structure, especially the outer walls, should be built of a material of low conductivity, so that as little heat as possible is lost from the setting. This question of insulation is now beginning to receive attention by the gas industry, and appears to be the most promising step which can be taken to increase the thermal efficiency of the plant. There is no single material which is sufficiently refractory and at the same time sufficiently insulating to serve that double purpose. It would be the practice, therefore, to place a layer of insulating bricks between the refractory lining and the outer walls.

RESISTANCE TO CHEMICAL ATTACK.

The retort material is exposed to the destructive action of the alkaline chlorides and volatile iron compounds which are liberated by many coals during carbonization. Though actual "running" may not occur, the fluxing of the surface of the refractory causes a difference in thermal expansion between the affected and unaffected portions, with a resulting increased tendency to spall. Some cases of "holing" of retorts have been attributed to slagging by the ash which is carried over from the producer lodging in the openings left by the falling out of jointing material.

A refractory which is basic in nature is less readily attacked by basic than by acidic substances, and *vice versa*. For example, a magnesite brick (basic refractory) will resist the attack by lime (basic substance), but will flux very readily with silica. A refractory which is neutral in nature will be more or less resistant to both acidic and basic substances. Though the question of the slagging of a refractory is thus primarily a chemical one, certain physical properties are also involved. Resistance to slagging is greater with a refractory of uniform and low porosity. Under certain conditions such factors as these may, conceivably, be as important as that of chemical nature. In this connection it may be noted that claims have been made that in gas-works practice silica brick (though more acidic than firebrick) is more resistant than firebrick to attack by alkalies and iron compounds (which are essentially basic). Judging from the chemical standpoint alone, one would expect the reverse condition to hold.

RESISTANCE TO ABRASION.

The mechanical strength of the retort material must be sufficient to withstand the abrasive action of the charge and coke. This requirement is secured by the correct grading and bonding of the raw materials to give a dense product. As this condition, however, tends to increase spalling, it is obvious that a compromise must be made. Firebrick is more resistant to abrasion than silica, and will stand up better to rough treatment with the rod.

RESISTANCE TO SPALLING.

When a material is subject to rapidly fluctuating temperatures, the forces of thermal expansion may be sufficient to bring about its disintegration. This may take the form of deep-seated cracking or of surface flaking. This tendency is more pronounced with a dense material (in which case the internal strains cannot be so easily accommodated in the pore spaces) and material of large or irregular thermal expansion. Owing to this latter reason, the heating up of a silica setting must be very gradual, as will be emphasized later. It will be recalled that, during scurfing, rapid combustion may cause a sudden large local rise in temperature and result in spalling trouble. It has been suggested that this rise in temperature during scurfing may be conveniently moderated by the introduction of a certain amount of steam along with the air. The gasification of carbon by steam, according to the equation $C + H_2O$ (steam) $= CO + H_2 - 29{,}000$ cals. requires the adsorption of heat, and will thus take up the excess heat generated by the rapid combustion.

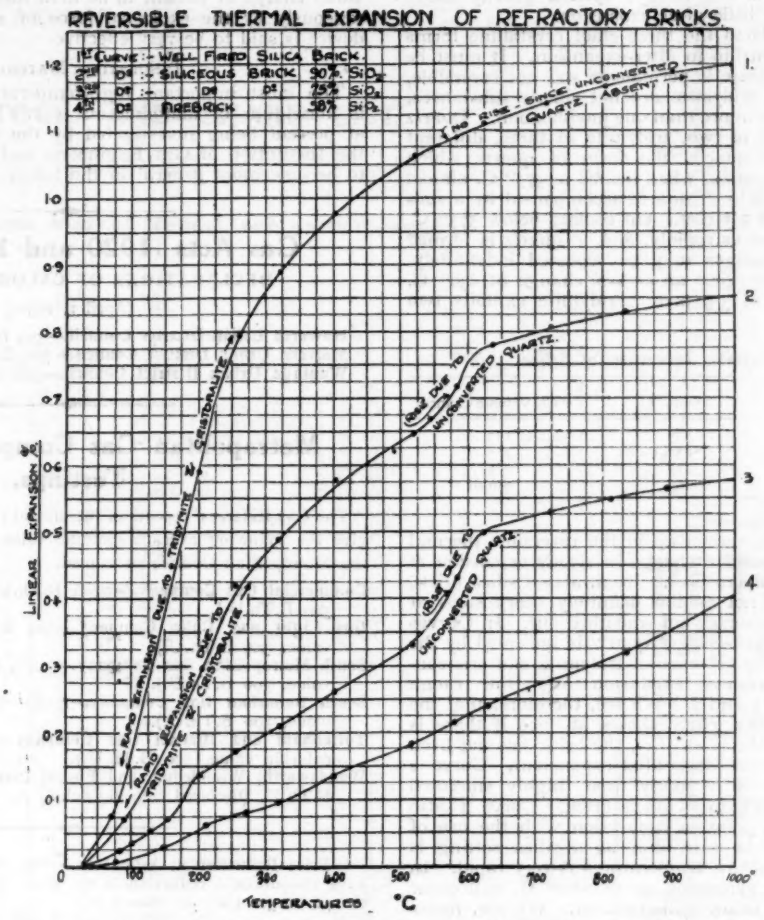
Shape and Size.—Good shape and accurate size are necessary that joints may be as thin as possible.

PHYSICAL PROPERTIES AND USE OF FIRECLAY REFRACTORIES.

As firebrick has a comparatively low underload refractoriness, its use is usually confined to those parts of the setting which are at low or moderate temperatures. In the combustion chamber, flues and cross walls, and in the hottest zone of a vertical retort, where the temperature may now approach or exceed 1400° C., the use of silica is to be recommended. In other parts of the setting firebrick can be used and has certain advantages over silica. The refractory used in the producer need have only moderate refractoriness, but it must be resistant to the slagging action of the ash and the abrasive action of the coke. These requirements are met by a dense firebrick. Owing to the fluctuation in the depth of the fuel bed in the producer the temperature of the lining may undergo severe changes. The firebrick must not, therefore, contain much free silica, especially in the form of quartz, for this causes the material to have a very irregular expansion, as is shown by Curves 2 and 3 in the figure.[1] The spalling tendency is thereby increased. The small and regular expansion of a satisfactory firebrick is illustrated by Curve 4.

The outer walls may be built of firebrick backed with insulating brick. If recuperators are incorporated in the setting,

[1] These tests were made in the laboratory at Leeds, and have been reported by Smith and Spiers, "JOURNAL," Vol. 184, p. 729.


REVERSIBLE THERMAL EXPANSION OF REFRACTORY BRICKS
1st CURVE :- WELL FIRED SILICA BRICK
2nd " :- SILICEOUS BRICK 90% SiO2
3rd " :- " " 75% SiO2
4th " :- FIREBRICK 58% SiO2
LINEAR EXPANSION %
TEMPERATURES °C
RAPID EXPANSION DUE TO TRIDYMITE & CRISTOBALITE
RAPID EXPANSION DUE TO TRIDYMITE & CRISTOBALITE
EXP. DUE TO UNCONVERTED QUARTZ
EXP. DUE TO UNCONVERTED QUARTZ
NO RISE - SINCE UNCONVERTED QUARTZ ABSENT

REVERSIBLE THERMAL EXPANSION OF REFRACTORY BRICKS.

these should be of dense firebrick, so that the heat interchange is facilitated by the increased conductivity of such material.

In some vertical settings where steaming is carried out, the lower courses of the retort built in firebrick are put to a very severe test. A firebrick may contain 3 p.ct. or more of ferric oxide, which is reduced to the ferrous form by the strongly reducing atmosphere of steam. It is well known that ferrous oxide slags very easily with silica, and this explains the bad running of the brickwork which sometimes occurs in steaming. The tendency will be less with materials containing less iron oxide, but with most materials troublesome roughening of the surface occurs. The steaming process probably transfers some iron oxide from the ash in the coke to the refractory, and in this way increases the slagging action.

Physical Properties and Use of Silica Materials.

Silica is now often used in the hottest parts of the setting, particularly in the combustion chamber and flues where the temperature may be as high as 1400° C. In a reported test a silica brick under a load of 25 lbs. per sq. in. did not fail until about 1650° C., whereas a firebrick failed at 200° C. lower. There is, therefore, less margin of safety in the use of firebrick at these hottest parts, especially as the figures quoted are for the temperatures of complete failure. Though a good silica brick will stand up satisfactorily to even more severe conditions if treated with due care during the heating up process, a badly burnt product is worse than useless. When silica was first introduced many cases of failure were due to both careless treatment and faulty material. Now that the complex nature of silica materials is more fully understood such failures should not occur.

The raw material from which a silica brick is manufactured is either quartzite or ganister, which are natural rocks containing as much as 97-99 p.ct. of silica. Now silica occurs in three distinct crystalline forms:

Table 1.—*Crystalline Forms of Silica.*

	Sp. Gr.
Quartz	2·65
Cristobalite	2·33
Tridymite	2·27

In quartzite and ganister silica occurs as quartz. This is the stable variety up to 870° C. Above this temperature quartz becomes unstable and begins to change into tridymite. The rate of change is very slow at 870° C., but becomes quite rapid at 1200° C., and is accelerated by the presence of certain fluxes, especially sodium tungstate. If the tridymite thus formed is now cooled to below 870° C. it does not change back into quartz, in spite of the fact that quartz is the stable form. The rate of change at low temperatures is so slow as to be negligible. If now the tridymite be heated to above 1470° C. it, in turn, becomes unstable and begins to change into the third form of silica—cristobalite. This form, like tridymite, once it is formed does not change back into quartz when it is cooled to ordinary temperatures.

It is obvious from the values of the specific gravities of the three forms of silica (Table 1) that their inter-conversion will be accompanied by large changes in volume. Table 2 shows the magnitude of these changes as calculated from the densities.

Table 2.

	P.Ct. Volume Change.
Quartz—tridymite	17
Quartz—cristobalite	14
Cristobalite—tridymite	2·6

When the raw or green silica brick is burnt in the kiln it is converted into a mixture of tridymite and cristobalite. Its volume will, therefore, increase in proportion to the extent to which the quartz is converted into the other forms of silica. The specific gravity of the brick is a useful guide as to the extent of conversion. When the brick has been fully converted, specific gravity will have fallen from 2·65 to about 2·32. It should be borne in mind that the specific gravity has this significance only when applied to bricks having a very high silica content—at least 95 p.ct. of SiO_2. Moreover, some cases have been noticed where the specific gravity was low, and yet other tests showed the presence of unconverted quartz. If the brick has not been burnt for a long enough time to a sufficiently high temperature to complete the conversion, in use it will continue to "grow" further until the conversion is complete. The amount it "grows" is called the "after-expansion," and is the subject of one of the standard tests. Such a brick will not, therefore, fulfil one of the requirements of a good refractory—constancy of volume, and if used may cause the distortion or even collapse of the structure.

Some years ago silica bricks were not so well fired as they are nowadays, and due allowance had to be made for subsequent growth by inserting packing pieces, which would burn out at working temperatures and provide the necessary expansion room. This practice is no longer required. A well

converted silica brick will not have a specific gravity above 2·36, and will show very little after expansion.

So far we have considered the three chief crystalline forms of silica and their relationship to after-expansion. It must be remembered that this change is permanent and not reversible. Quartz, cristobalite, and tridymite are not simple substances, but can themselves exist in more than one modification. Quartz and cristobalite can exist in two, tridymite in three, different forms. For example α quartz, the form of quartz which exists at ordinary temperatures, when heated to 575° C. almost instantaneously changes into β quartz accompanied by a sudden increase in volume of 1·3 p.ct. On cooling below 575° C. the change is reversed just as rapidly, and α quartz is formed again. This cycle of changes may be repeated indefinitely. Similarly, cristobalite undergoes an $\alpha \rightarrow \beta$ change at 230° C. with a volume increase of 3·5 p.ct. Tridymite exhibits two such changes.

TABLE 3.—*Reversible Inversions of Silica.*

—	Temp. °C.	P.Ct. Volume Change.
$\alpha \rightarrow \beta$ Quartz	575	1·3
$\alpha \rightarrow \beta$ Cristobalite . . .	230	3·5
$\alpha \rightarrow \beta_1$ Tridymite . . .	113	0·5
$\beta_1 \rightarrow \beta_2$ "	163	Small

These changes are clearly shown up in the reversible thermal expansion curves by the sudden change in steady expansion at the so-called inversion temperatures. In an actual silica brick, however, the curve does not exhibit definitely sharp steps at the inversion points but is somewhat smoothed out. In Curves 2 and 3 in the figure the presence of quartz is indicated by the step at about 575° C. The presence of tridymite and cristobalite is shown by an increased expansion over the range 100-300° C. as in Curves 1 and 2. We see, therefore, that the reversible thermal expansion curve shows at once if there is free quartz remaining in the brick (*i.e.*, the brick has not been well burnt and will give a large after-expansion). Curve 2 illustrates the behaviour of a poorly fired (highly siliceous) brick, and Curve 1 a well fired silica brick. Curve 1 also emphasizes an important point in connection with the use of silica materials. It will be seen that as a silica setting is heated up the expansion at low temperatures is very rapid. In fact, 75 p.ct. of the total expansion up to 1000° C. will occur below 300° C.—*i.e.*, well below dull red heat. We see, therefore, that unless the heating from cold to 300 or 400° C. is very gradual and uniform, very serious spalling will occur. This fact was not at first appreciated, and in some instances the structure had failed completely by the time the working temperature had been reached. The danger is that the damage is done before the heat becomes visible. The heating up of a silica setting should take three or four weeks to reach dull red heat, and should be followed by means of a thermocouple pyrometer. After dull red heat is reached the heating may be rapid. As these volume changes in a well burnt silica brick are reversible, equal care should be taken in cooling down the setting below red heat.

SILICEOUS MATERIALS.

An ordinary firebrick will contain about 60 p.ct. of silica and a silica brick 93 p.ct. or more. Intermediate between these two types are the so-called siliceous bricks. The raw materials are natural siliceous fireclays, or "clayey" silica rocks. In some cases crushed silica rock is added to ordinary fireclay in order to increase the silica content. Generally speaking, the properties of siliceous bricks are intermediate between those of ordinary firebricks and silica bricks. It must be pointed out that quartz will show the characteristic behaviour described in the previous paragraph in whatever type of refractory it occurs. Therefore, the conditions which must be observed in the burning and use of silica brick will also apply (to a less degree) to siliceous brick, whether the quartz occurs naturally with the clay or is added as crushed quartz rock.

JOINTING MATERIALS.

The weakest points in any refractory structure are the joints, and their failure is undoubtedly the beginning of most cases of retort "holing." If the jointing material falls out or runs out, the cavity so left serves to collect ash, which soon forms a pool of very corrosive flux. The properties which a satisfactory jointing cement must possess are many and varied. The problem of obtaining the best compromise is discussed by Edwards[2] in a recent paper, and will not be dealt with here at length. Among the tests which should be carried out are those for working qualities, grain size, shrinkage, adherence, dry and fired strengths, and refractoriness.

HOT PATCHING.

The patching of a hot retort by hand is a difficult task, because the cement cannot be rammed firmly into position before it has dried up and become unworkable. Recently, a form of hot patching "gun" has come into use, enabling a small charge of cement to be fired into position almost instantaneously by the explosive force of a small cartridge. This device is said to be very effective.

[2] Journal of the Ceramic Society, October, 1929.

INSULATING MATERIALS.

The most important high-temperature insulating material is kieselguhr or diatomaceous earth. Its testing and use is at present being investigated by the Research Committee of the Institution of Gas Engineers, and its application is likely to become more general in the future.

Gas Acts (1920 and 1929) Orders.

DECLARATIONS OF CALORIFIC VALUE.

(April 1, 1930.)

Haworth Urban District Council.—500 B.Th.U.
Malvern Urban District Council.—500 B.Th.U.
Wantage Urban District Council.—500 B.Th.U.

Metropolitan Gas Companies' Official Testings.

The Gas Referees' reports of the official testings for the past quarter give the following average calorific values for the gas supplied by the Metropolitan Companies named.

Commercial Gas Company.—503·4 B.Th.U. (declared calorific value, 500 B.Th.U.).
Gas Light and Coke Company.—504 B.Th.U. (declared calorific value, 500 B.Th.U.).
South Metropolitan Gas Company.—561·3 B.Th.U. (declared calorific value, 560 B.Th.U.).
South Suburban Gas Company.—503·7 B.Th.U. (declared calorific value, 500 B.Th.U.).
Tottenham and District Gas Company.—501·7 B.Th.U. (declared calorific value, 500 B.Th.U.).
Wandsworth, Wimbledon, and Epsom District Gas Company.—471·4 B.Th.U. (declared calorific value, 470 B.Th.U.).

Price Reduction at Ashburton.—The Ashburton Gas Department have announced a reduction in the price of gas as from Jan. 1 from 6s. 4d. to 5s. 11d. per 1000 c.ft.

Newbiggin to be Lit by Gas.—The Newbiggin Council have accepted the recommendation of the Improvements Committee to accept the terms of the Gas Company for street lighting. This decision was arrived at after a comparison had been made with the electric lighting figures.

Improvements at Ballymena.—As funds will permit, considerable enlargements and improvements are to be carried out at Ballymena Gas-Works which will cost about £2000. The scheme includes the re-construction or re-modelling of existing offices and showrooms and enlarging the entrance to the gas-works.

No Pennies, No Gas.—A letter appearing recently in the "Dundee Advertiser" drew attention to the inconvenience caused by lack of coppers for the prepayment meters. People are often handicapped during winter months, it was stated, by a dearth of copper change. It is a fact that numerous householders, failing to get pennies, have often to resort to lamps and candles. The suggested solution of this difficulty is the emptying of the meters more frequently.

Sheffield Illumination Society.—Mr. J. F. Colquhoun, President of the Sheffield Illumination Society, presided at a social evening of the Society in Stephenson's Restaurant on Jan. 20. He pointed out that the membership of the Society was now 105, an increase of 20 over last year, and referred to a change of syllabus from previous years. In future the lectures will be given by members of the Corporation Lighting Department staff, and not by visitors as formerly. Over 100 members were present, and a concert and whist drive followed.

King's Patent Agency, Ltd.—Though the Company has just celebrated its coming of age (having been incorporated in the year 1908). Mr. B. T. King (Managing Director) personally has been actively engaged in the patenting of inventions and the registration of trade marks for over 43 years, having been articled in 1886. The Secretary (Mr. Robert Hunter) has for many years been registered as a Patent Agent; the Technical Manager (Mr. E. C. Axe) is also duly qualified as a Patent Agent; while Mr. King's youngest son (Mr. B. T. King, jun.), after obtaining his higher school certificate and practical engineering experience, is now engaged with the firm, and hopes also to qualify as a Patent Agent.

Owing to a failure of the electricity supply, Leicester was in almost complete darkness for about half-an-hour on the evening of Jan. 20.

The gas sold during December by the Kendal Gas and Water Department showed an increase of 2,122,500 c.ft. over that sold during the same period in the previous year—equivalent to 13·44 p.ct.

We have to acknowledge the receipt from Messrs. W. G. Beaumont & Son, Priory Works, Bow, E. 3, of a copy of their excellent Year Book for 1930. It is interesting to note that this is the 22nd edition of this useful office companion.

STOCK AND SHARE LIST.

[For Stock Market Report, see earlier pages.]

Issue.	Share.	When ex-Dividend.	Dividends. Prev. Hf. Yr.	Dividends. Last Hf. Yr.	NAME.	Quotations. Jan. 17.	Rise or Fall on Week.	Transactions Lowest and Highest Prices During the Week.
£			% p.a.	% p.a.				
171,978	Stk.	Aug. 15	5	5	Aldershot 5 p.c. max. C. .	70–75	..	74
412,992	,,	,,	4	4	Do. 4 p.c. Pref. . .	71–74	..	..
1,551,868	,,	Sept. 26	7⅝	7⅝	Alliance & Dublin Ord. . .	93–96	..	99½–95
374,000	,,	Jan. 9	4	4	Do. 4 p.c. Deb. . .	60–63*	..	..
522,655	,,	Aug. 29	7	7	Barnet Ord. 7 p.c.	112–115	..	..
800,000	1	Oct. 24	1/4⅛	1/4⅛	Bombay, Ltd	16/- - 18/-	..	..
172,500	10	Aug. 29	8½	9	Bournemouth 5 p.c. . . .	13–13½	..	..
500,050	10	,,	7	7	Do. B 7 p.c. . . .	12⅝–12⅞	..	..
439,160	10	,,	6	6	Do. Pref. 6 p.c. .	10⅞–11⅛	+⅛	..
50,000	Stk.	Dec. 19	3	3	Do. 3 p.c. Deb. .	53–56	..	..
162,025	,,	,,	4	4	Do. 4 p.c. Deb. .	72–75	..	..
357,900	,,	Aug. 29	7½	7½	Brighton & Hove 6 p.c. Con.	113–116	..	114–115
871,880	,,	,,	6½	6½	Do. 5 p.c. Con.	100–103	..	..
1,287,500	,,	July 25	5	5	Bristol 5 p.c. max.	86–87*a*	+½	..
855,000	,,	Sept. 12	7½	7	British Ord.	113–117	..	113½–114
100,000	,,	Dec. 19	7	7	Do. 7 p.c. Pref. . . .	109–114	..	..
120,000	,,	,,	4	4	Do. 4 p.c. Red. Deb. . .	69–71	..	..
450,000	,,	,,	5	5	Do. 5 p.c. Red. Deb. . .	92–95	..	..
100.000	,,	Jan. 9	5	5	Cambridge 5 p.c. Deb. . .	88–91*	..	..
100.000	10	Dec. 5	8	6	Cape Town, Ltd.	8½–9½	..	9
100.000	10	Nov. 7	4½	4½	Do. 4½ p.c. Pref. . .	6⅝–7½	..	6½
150,000	Stk.	Dec. 19	4½	4½	Do. 4½ p.c. Deb. . .	69–74	..	..
626.860	,,	July 25	6	6	Cardiff Con. Ord.	98–101	..	..
237 860	,,	Jan. 9	7½	7½	Do. 7½ p.c. Red. Deb. .	97–100*	..	..
157,150	,,	Aug. 15	6⅔	5	Chester 5 p.c. Ord.. . . .	90–95*b*	+3	..
98 986.	1	Oct. 10	†2/-	†2/-	Colombo, Ltd. Ord. . . .	34/—36/-	..	..
24 495	1	,,	1/4⅛	1/4⅛	Do. 7 p.c. Pref. .	19/—21/-	..	..
375,402	1	Oct. 10	1/9⅝	1/9⅝	Colonial Gas Assn. Ld. Ord.	21/6–23/6	–2/-	..
187,848	1	,,	1/7½	1/7½	Do. 8 p.c. Pref.	20/—22/-	..	..
2.073.280	Stk.	July 25	7	5	Commercial Ord.	90–95	..	9½
475,000	,,	Dec. 19	3	3	Do. 3 p.c. Deb . .	54–57	..	..
787,560	,,	Aug. 15	7	7	Croydon sliding scale. . .	104–107	..	105½–106½
403,100	,,	,,	5	5	Do. max. div. . . .	80–85	..	..
542 270	,,	Aug. 29	10	7	Derby Con.	118–121*e*	..	..
55,000	,,	Dec. 19	4	4	Do. Deb.	67–70*e*	..	..
209 000	,,	Aug. 29	5	5	East Hull Ord. 5 p.c. . . .	73–75	..	..
1,002,180	10	Sept. 12	†7	†4	European, Ltd.	13–15	+½	13½–14½
18,708,480	Stk.	July 25	5⅜	5⅜	Gas Light & Coke 4 p.c. Ord.	18/3–18/9*f*	+1½	18/1½–18/10½
2,600,000	,,	,,	3½	3½	Do. 3½ p.c. max. . . .	60–62	..	61–6*d*
4,157.020	,,	,,	4	4	Do. 4 p.c. Con. Pref. . .	75–78	+1	76½–77½
5,602,620	,,	Dec. 19	3	3	Do. 3 p.c. Con. Deb. . .	56–58	..	57–58
3,642,770	,,	,,	5	5	Do. 5 p.c. Red. Deb. . .	97–100	..	98½–99½
82,500	,,	Aug. 29	7	7	Hastings & St. L. 5 p.c. Conv.	98–103	..	..
258,740	,,	,,	5½	5½	Do. 3½ p.c. Conv.	77–82	..	..
70.000	10	Oct. 10	†10	†10	Hongkong & China, Ltd. .	13½–14½	..	..
213,200	Stk.	Aug. 29	6	6½	Hornsey Con. 3½ p.c. . . .	84–87	..	..
1,976,000	,,	Nov. 21	20	10	Imperial Continental Cap. .	350–370	+5	345–375
228,180	,,	Aug. 15	3½	3½	Do. 3½ p.c. Red. Deb.	71–76	..	..
235,242	,,	Aug. 15	7½	8	Lea Bridge 5 p.c. Ord. . .	115–118	..	..
2,145,907	,,	Aug. 15	6½	6	Liverpool 5 p.c. Ord. . . .	91–92*b*	..	..
600.000	,,	Sept. 26	7	7	Do. 7 p.c. Red Pref .	100½–102½*b*	..	..
165,736	,,	Aug. 29	8	9	Maidstone 5 p.c. Cap. . .	122–127	..	..
63,480	,,	Dec. 19	3	3	Do. 3 p.c. Deb. . .	52–55	..	..
75,000	5	Dec. 5	†10	†10	Malta & Mediterranean . .	5½–6	..	..
392,000	—	Oct. 1	5½	5½	Metrop'itan (of Melbourne) 5½ p.c. Red. Deb. . . .	92–95	..	..
541,920	Stk.	Nov. 21	†9	†6	Montevideo, Ltd.	107–112	+2	105–109½
2,061,315	,,	July 25	5⅝	5	Newcastle & Gateshead Con.	15/9–16/3*df*	..	..
682,856	,,	,,	4	4	Do. 4 p.c. Pref. .	71½–72½*d*	..	..
691,705	,,	Dec. 19	3½	3½	Do. 3½ p.c. Deb. .	65½–66½*d*	..	..
131,780	,,	Aug. 29	7/1/0	7½	North Middlesex 6 p.c. Con.	112–117	..	..
396,160	,,	Aug. 15	5	5	Northampton 5 p.c. max. .	76–79	..	..
300,000	,,	Nov. 21	7	9	Oriental, Ltd.	108–113	..	112
60,000	5	13 My., '15	—	—	Ottoman	0–½	..	..
205,162	Stk.	Jan. 9	8	8	Plym'th & Stonehouse 5 p.c.	107–110*	..	..
424,416	,,	Aug. 29	8½	8	Portsm'th Con. Stk. 4 p.c. Std	113–118	..	..
241,446	,,	,,	5	5	Do. 5 p.c. max. . .	80–83	..	..
2 334.464	1	June 27	—	‡5	Primitiva Ord.	28/6–30/6	+/6	..
244,500	100	Dec. 2	4	4	Do. 4 p.c. Red. Deb. . .	91–94	..	..
695,000	Stk.	July 25	4	4	Do. 4 p.c. Red. Deb. 1911	79–82	..	81–82
416,345	,,	Dec. 19	4	4	Do. 4 p.c. Cons. Deb. .	77–80	..	..
150,000	10	Sept. 26	6	6	San Paulo 6 p.c. Pref. . .	8⅜–9½	+⅛	8⅛
1.736,968	Stk.	Aug. 29	6¼	6¼	Sheffield Cons.	104–106*e*	..	..
95,000	,,	Jan. 9	4	4	Do. 4 p.c. Deb.	74–76*e**	..	..
90.000	10	June 13	‡4	‡4	South African	4–6	..	..
6,609.895	Stk.	July 26	7½	5	South Met. Ord.	99–101	..	100–101
500,000	,,	,,	6	6	Do. 6 p.c. Irred. Pf.	106–109	..	..
1,895,445	,,	Jan. 9	3	3	Do. 3 p.c. Deb. . .	53–56*	..	54½–55
734,000	,,	Sept. 12	6½	6½	Do. 6½ p.c. Red. Db.	98–100	..	100
91,500	,,	Aug. 15	8½	8½	South Shields Con. . . .	109–111*d*	..	..
1,543,795	,,	July 25	6½	6½	South Suburban Ord. 5 p.c.	101–104	..	..
468,837	,,	Dec. 19	5	5	Do. 5 p.c. Deb.	92–95	..	94–95
647,740	,,	Aug. 15	5	5	Southampton Ord. 5 p.c. max.	77–80	..	79–79½
121,275	,,	Dec. 19	4	4	Do. 4 p.c. Deb.	68–71	..	..
179,014	,,	July 25	8	8	Sutton Ord.	116–119	..	..
67,828	,,	Jan. 9	5	5	Do. 5 p.c. Deb. . .	88–91*	..	..
250,000	,,	Feb. 21	7	7	Swansea 7 p.c. Red. Pref. .	100–102	..	..
200,000	,,	Dec. 19	6½	6½	Do. 6½ p.c. Red. Deb. .	97–99	..	..
1,002,275	,,	Aug. 15	6⅔	6⅔	Tottenham District Ord. .	101–106	..	£102–105
150,000	,,	,,	5⅓	5⅓	Do. 5⅓ p.c. Pref. . .	97–100	..	..
181,255	,,	Dec. 5	4	4	Do. 4 p.c. Deb. . .	72–75	..	..
182,380	10	30 Dec., '12	—	—	Tuscan, Ltd.	3¾–4¼	..	..
87,701	Stk.	Sept. 26	6	6	Do. 6 p.c. Red. Deb.	75–80	..	..
280,094	,,	Aug. 29	7	7	Uxbridge, Maidenhead, & Wycombe 5 p.c.	97–102	..	..
88,336	,,	,,	5	5	Do. 5 p.c. pref. . .	85–90	..	..
1,180 970	,,	—	—	—	Wandsworth, Wimbledon, and Epsom Cons. . .	105–110	..	105–107½
200,000	,,	July 11	5	5	Do. 5 p.c. Pref.	87–92	..	..
488,344	,,	Dec. 19	5	5	Do. 5 p.c. Deb.	91–95	..	91½

Quotations at:—*a.*—Bristol. *b.*—Liverpool. *c.*—Nottingham. *d.*—Newcastle. *e.*—Sheffield. *f.*—The quotation is per £1 of Stock. * Ex. div. † Paid free of income-tax. ‡ For year.

(This announcement is inserted gratuitously.)

PETER—WITH ONE EXCEPTION

With one exception Peter is an ordinary little fellow. Chubby, likeable, just five-and-a-half, full of life and fun and on occasions—be it admitted—of naughtiness.

Just now Peter's rather important, for this is his first term at school, and he's grappling with the intricacies of "A B C" and "Twice Two": difficult subjects to all men of five-and-a-half, but even more difficult in Peter's case because—bad luck—he's totally blind. That's his One Exception.

Peter learns reading, writing, and 'rithmetic through the medium of "Braille"—dull stuff compared with the coloured picture books of most five-and-a-halfs. However, he's a stout lad is Peter, and he's making great progress.

Would you like to know more about him? How, in spite of his "One Exception," he is being educated, and, when older, technically trained and usefully employed.

There is a long waiting list of "Peters" throughout the British Isles, for whom training and accommodation must be provided in the immediate future.

Will you help with a donation or annual subscription? Any sum, large or small, will be gratefully received.

Here's a suggestion. Your eyesight is worth 3d. a year to you. Send Peter and his handicapped pals 3d. for every year you've had it. Now, please, in case it slips your memory. Good idea!

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F. R. THOMAS,
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A. H. JACKSON,
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NOTICE is Hereby Given that an ORDINARY GENERAL MEETING of the Proprietors of this Company will be held at this Office on Friday, the 7th day of February next, at Twelve o'clock (noon) precisely, to transact the usual Business, including the Declaration of a Dividend for the Half-Year ended on the 31st day of December last, and to Elect Directors and Auditors in the place of those who will at such Meeting go out of Office in compliance with the Company's Acts or Schemes of Amalgamation.
By order,
WILLIAM LYLE GALBRAITH,
Secretary.
Chief Office:
Horseferry Road,
Westminster, S.W. 1,
Jan. 20, 1930.

SOUTH METROPOLITAN GAS COMPANY.

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NOTICE IS HEREBY ALSO GIVEN that at such Meeting Resolutions will be submitted for the Creation and Issue of further Ordinary or Preference and Debenture Stock, as authorized by the South Metropolitan Gas Act, 1928.
The TRANSFER BOOKS WILL BE CLOSED for both PREFERENCE and ORDINARY STOCKS on and from the 29th day of January inst. until after the Meeting.
By order,
FRANK DAY,
Secretary.
Offices:
709, Old Kent Road,
London, S.E. 15,
Jan. 18, 1930.

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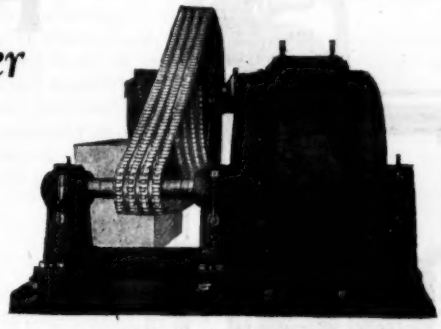

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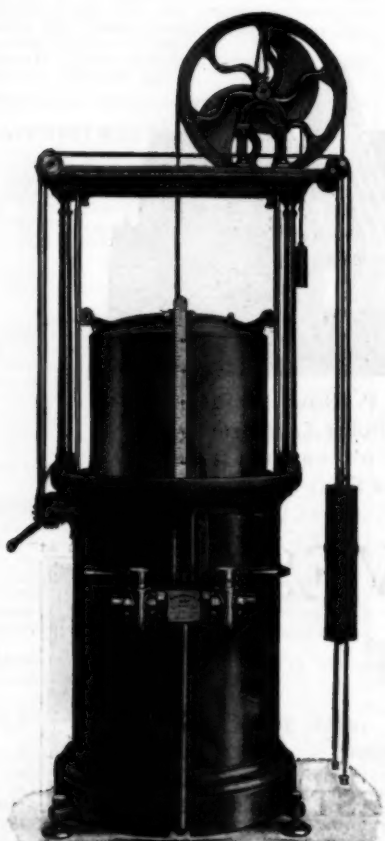

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